Concrete

Vol. 22 *Detroit, April, 1923* *No. 4*

As Painless as Possible

A WARNING that is being sounded to the whole world of business has special significance in the construction field.

We are rapidly being encompassed by all the dangers of "a boom".

It is in the nature of a boom to blow up.

A good deal of building is in progress. There is so much under way that there is a tendency to get "heady". We are threatened with a runaway market. Prices of both labor and materials are rising. It will be a good thing for business if we profit by things learned in 1920. If labor will stay reasonable; if producers will stay reasonable; if dealers will stay reasonable; if contractors will stay reasonable—the demand for construction will remain active. It will remain active because there is a real need for construction. If we don't stay reasonable demand will get its dander up and quit. It will wait. It is used to waiting. Been waiting now for years. Then there will be another slump and nobody will make as much money as he might make if business *stays* cool-headed.

Good business isn't done by short booms and long waits, but by steady plugging. Not by temporary big profits but by continued small profits.

Let's do what we can to keep the public in a building frame of mind, by making building as painless as possible.

Yesterday and Today in the Products Business

THESE are great days for concrete building units. Long ago a decree was entered against the one-horse, back-yard block manufacturer. There were sound reasons. First, because, in a one-horse way, a man can't make concrete building units, make them as they should be made and compete in an average market with previously established materials; second, because as long as a business is so easy to get into there are too many in it and a majority of them not of a calibre to make the uphill fight that a new material has always to make against traditions.

No new industry pops up full-fledged over night. The small operator has to come first. The back-yard block manufacturers were inevitable. Most of them had to fail so that a few might establish an industry. Nowadays the machinery people are actually selecting their customers—"picking the winners". Their imaginations have been fired. They see big possibilities. When they sell machinery now they want to make sure, not only that the buyer has the money to pay for it, but money to house it, to manage it, operate it with all the necessary auxiliary equipment—operate it to make a big output and a proper, safe, going enterprise, one that will expand and provide for more machinery of the same kind. Such practice is not yet the universal practice but it is getting there because it is the practice that survives.

So it is that the men you see going into the block business nowadays are quite different from the average novices at such an undertaking ten years ago. Nowadays they are men who are putting $20,000 to $100,000 into a manufacturing enterprise. They visit plant after plant to see what there is. They buy machinery for continuous production service. They see it set up and *proved* in their own plants before the transaction is complete. It wasn't like that in the olden days.

Roof Tile

THEN there are roof tile. Making roof tile as a side line with one hand machine is a manufacturing travesty. The man who thinks he is setting up in the roof tile business with one little machine and enough pallets for half a day's run *may* deserve the disillusionment that is coming to him. Men usually suffer for their ignorance sooner or later.

One of the most promising things about the roof tile business as with other concrete product lines is that it is being taken much more seriously by people capable of serious thought. A man(or a small group) doesn't often invest ten to forty thousand dollars in a business without reckoning somewhat the hazards. He isn't going into business that way without some leeway beyond his initial investment in plant, to see the thing through. A man who invests seriously and heavily in the products business doesn't junk the whole thing at the first set-back. And by the same token he is the kind of chap who knows that establishing a new business and keeping it established means standard, satisfactory quality in product.

That kind of manufacturer isn't likely to be greatly influenced by the narrow, short-sighted policy that has often been evident in the past among machinery manufacturers who coddled their competitive wrath and back-bit their fellow manufacturers. This has put us a decade behind where the industry might now be.

Now We Have Capital, Let's Have Knowledge

THE products field is learning. It has been a rough road but it is smoother now. The products manufacturer is learning that no matter what machines and systems and patents he is using, no matter what ours-is-the-one-and-only equipment he has, there are certain fundamental problems in the products business still to be solved. These fundamental problems bind him like a brother to other products manufacturers who hold a different machinery faith.

The fellow who is sufficient unto himself, who knows it all, hasn't found even the beginning of wisdom.

So the products men are organizing in various cities and states on what begins to look like a workable basis, organizing to maintain quality and to exchange information on how their products are to be established on that basis. They don't need to organize to maintain prices even if it were lawful. If they maintain quality, price takes care of itself.

The leaders, the more progressive of these products manufacturers, aren't stopping with organization among themselves. They are reaching out for more knowledge and in reaching they find it isn't all among themselves. Their products are made of concrete, and the problems of concrete are the problems of other men who aren't products manufacturers. They are going to laboratories and experts with their problems—problems of bigger production, economy of material, of basic quality.

Thus with more capital and broader-mindedness the concrete products industry is finding itself.

Some Products Questions

THE American Concrete Institute is forming a new committee on concrete roof tile which will undertake to solve the color and curing problems. "Why should I pay 14c for color when I can buy some that seems to be as good for 5c?" says the roof tile man. "Why does your tile keep its color and mine fade?" is the next question. Most manufacturers don't know *what* color to use and very few indeed know *why*. The committee will be charged with the job of finding out.

Under what conditions should lift trucks be used in moving concrete products in the factory and under what conditions should tracks and cars be employed?

What kind of curing methods should be used in products manufacture? A few years ago a good many of us gave the answer glibly enough. Now we aren't sure. Methods commonly in use are wasteful of invested capital and operating efficiency. What method gets the best results for the least money?

Such is the substance of several recent inquiries sent to this magazine. The questions are being turned over to the Advisory Committee of the American Concrete Institute with the suggestion that they would make good subject matter for study this year by the Committee on Products Plant Operation.

Have you a question? Send it in. If the answer isn't available, we'll submit it respectfully to the American Concrete Institute. That's what the Institute is for.

Wisconsin Products Manufacturers Hold Convention

The first convention of the Wisconsin Concrete Products Manufacturers held at the Hotel Pfister, Milwaukee, February 20 and 21, was very successful. A total of 107 registered, of whom 65 were products manufacturers. Every section of the state, except the extreme northwestern section, was represented. There were also 17 machinery manufacturers' representatives present.

Phil Grau, business director of the Milwaukee Association of Commerce, spoke on the desirability of a permanent organization for which there was manifest demand. One of the first matters of business was the appointment of a committee to draw up resolutions and by-laws. The Wisconsin Concrete Products Association was formed in the afternoon, and at the end of the day the membership list showed 38 members and 9 affiliate members. Full memberships are open to products manufacturers at $25 per year and affiliate memberships to machinery representatives and others at $5.00 per year.

Officers elected are: W. H. Carey, Wisconsin Rapids, president; George C. Yunker, Milwaukee, vice-president; D. R. Collins, Milwaukee, secretary-treasurer. The following district representatives were also elected: I. J. Westerveld, Wausau; G. J. Lengst, Prairie du Chien; C. O. Gochnauer, Appleton; Julius Sorenson, Racine; George Luety, Beloit; G. A. Aschbrenner, Milwaukee.

The committee report on which organization was based set forth the following objects:

1. *Bettering Quality of Products.* A systematic campaign be carried on with concrete products manufacturers throughout the state with the idea of helping them to better the quality of their products and thereby gain public confidence; to be accomplished through periodic tests of products by accredited testing laboratories and through helping products manufacturers with problems relative to manufacturing methods.

2. *Publicity.* A wide-spread publicity campaign be carried on by this organization through the press in towns where concrete products plants are located, by means of which the public would be acquainted with the merits of our products. The material to be furnished the press is to be furnished by this Association to its members in a series of letters dealing with the various phases of the concrete products industry.

3. *Work with Architects, Contractors and Builders.* To work with architects, contractors and builders to show and convince them of the merits of our product and have it specified wherever possible.

4. *Monthly Bulletin.* Publication by this Association of a monthly bulletin similar to that published by the Iowa Concrete Products Association, to serve as a medium for the interchange of ideas on manufacturing and merchandising problems. It will also serve as the voice of the concrete products industry in Wisconsin.

5. *Affiliation with the National Association.* Affiliation with the National Concrete Products Association allowing members to participate in the benefits of the national organization.

6. *Building Codes.* To work with city and state officials to see that concrete block and other structural units are given proper recognition in building codes and to support the proper officials in their enforcement of such codes.

7. *House Construction.* To work to further the use of concrete block above the grade line, particularly for dwelling house construction.

8. *Advertising.* To furnish as desired by its members suitable advertising copy and campaigns which will draw attention to concrete products and result in a greater volume of sales.

Paving a 34-Degree Slope With Concrete

By A. C. D. Blanchard
Chief Field Engineer
Queenston-Chippewa Power Development

The construction of the canal of the Queenston-Chippewa Power Development involved many problems which could not be satisfactorily solved until it was possible to effect try-outs on the ground to establish the most efficient and economical method of procedure. This was due principally to the exceptional magnitude of the component parts of the work and to the necessity of applying not only the most advanced methods hitherto developed, but frequently adapting methods originating with the Commission's staff, both in field and office, to achieve the purpose in view.

Some of these problems, such as the method of proportioning concrete successfully employed on this work, have been described by Mr. R. B. Young, in articles published in Concrete in July and November, 1922, and it is now intended to describe briefly one of these exceptional features, the importance of which merits the setting apart of a special article to fully describe the problem encountered, and the methods finally adopted to secure its solution.

Previous articles have already described the physical characteristics of the 8½-mi. rock section of the canal which was excavated in vertical cut and surfaced on bottom and sides with a thin lining of concrete. About 2½ mi. from the lower end of the canal, the rock surface drops below the gradient of the bottom of the canal, which condition extends for a distance of about three-fifths of a mile. This depression of the rock constituted an old river channel which originated near the Niagara Whirlpool and ran across country intercepting the located line of the canal approximately at right angles. The gorge thus formed became filled with glacial drift, which in recent times was partly eroded to form a deep, narrow ravine through which a small creek discharged into the Whirlpool.

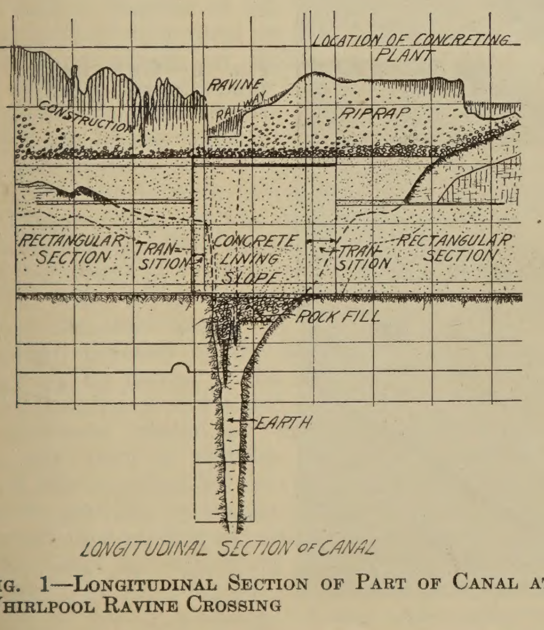

Fig. 1—Longitudinal Section of Part of Canal at Whirlpool Ravine Crossing

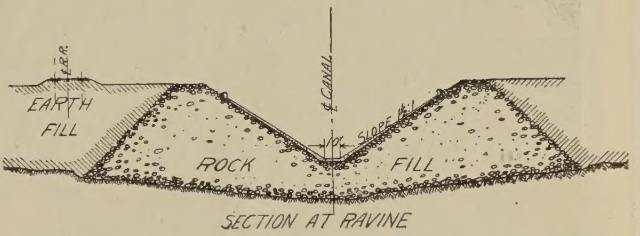

Fig. 2—Cross-Section of Canal in Ravine Showing Rock Fill Backing and Sloped Lining

Fig. 1 shows the outline of the surface of the rock sides of the prehistoric channel, the surface of the overlaying earth as it was at the beginning of operations, the grade line of the canal and other features.

The material overlaying the rock was a very fine sand carrying a small amount of clay. It had the peculiar characteristic of retaining water when saturated and was very unstable. It was somewhat compressible and was objectionable even as a foundation for receiving a heavy fill. Obviously it was unsuitable as a foundation for masonry, and in places this deposit was so deep as to afford no support for any reasonable length of piling. The standard rectangular section in this locality was therefore out of the question.

After exhaustive study of the conditions likely to be encountered, a design was adopted providing for a "V" shaped channel shaped in heavy rock fills, with transition sections in the solid rock at both ends to tie to the usual rectangular concrete-lined section; the sloping sides to be backed with rock fill, carried down 8 ft. below finished canal grade, and spread out in the ravine bottom about 600 ft. (Fig. 2). This had the effect of a rock fill dam on each side of the centre with a base of 300 ft. and the whole of the rest of the ravine, within a quarter of a mile in each direction, was filled up with earth and rock spoil from the canal excavation. Where the earth formed the sides of the excavation, the cut was made ample for a large quantity of loose rock backfill on each side. This material was deposited as soon as possible to allow time for settlement and the surface was ready for trimming to line some time before concreting operations started. Furthermore, the concreting of the lining for the bottom and slopes was left over until the last season's work. Full settlement was thus obtained prior to the final operation of placing the concrete lining, with which this description has particularly to do.

Prior to placing the lining, the slopes were trimmed

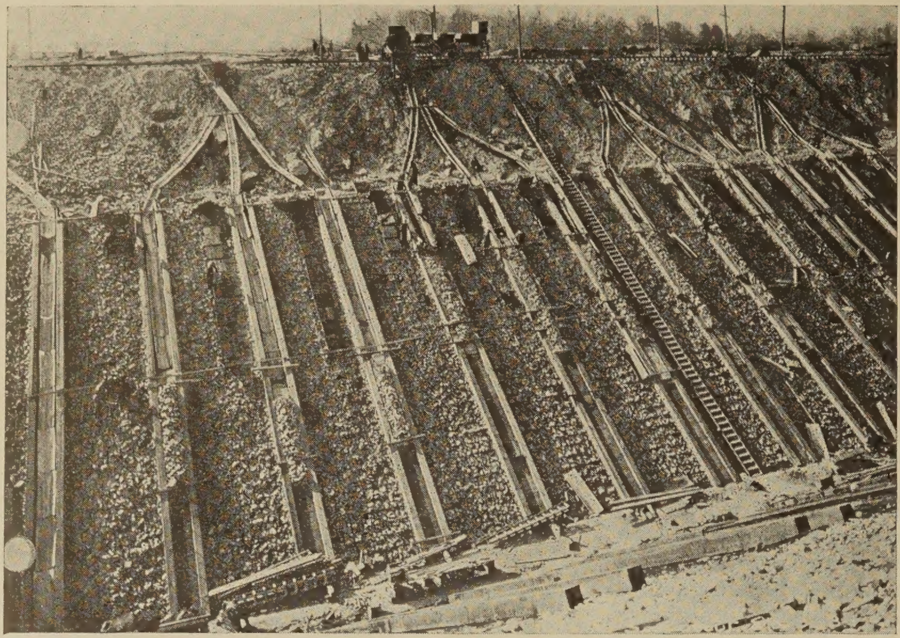

Fig. 3—Advance Construction of Guide Strips, Arrangement of Chutes and Concrete Car

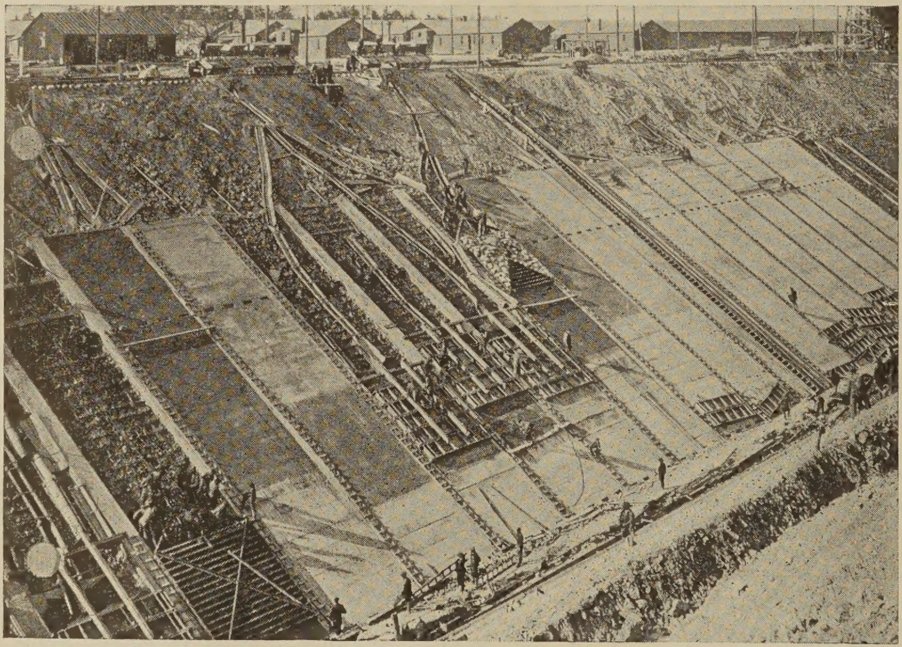

Fig. 4—Wooden Panels and Movable Steel Forms in Operation

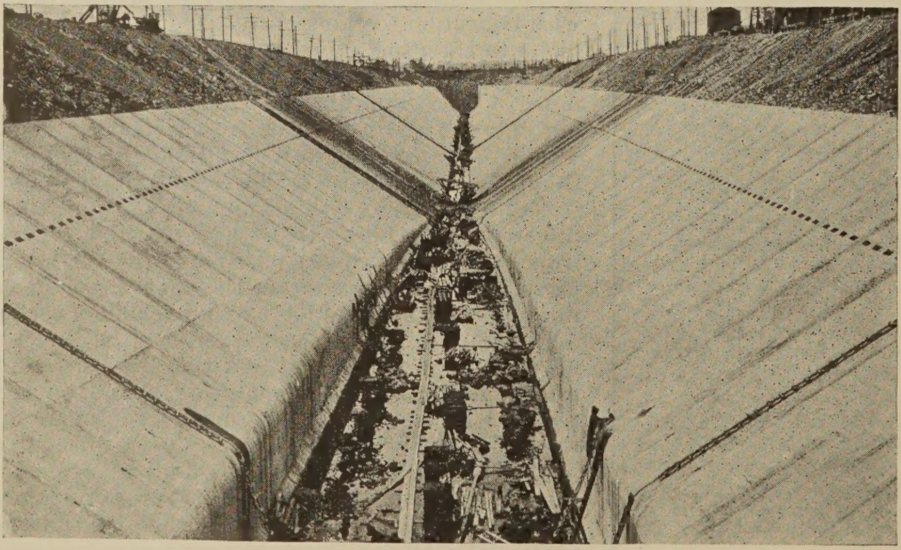

Fig. 6—General View of the Completed Work

by hand to correct line and all large voids filled with smaller stones to prevent excessive leakage of concrete.

Round steel bars of ¾-in. section were laid in both vertical and longitudinal directions and spaced at 18-in. and 24-in. centres, respectively. This steel was assembled on the trimmed surface and in practice was found to be supported on scattered points of rock, giving sufficient room for the concrete to flow in behind and secure a bond, without further adjustment.

The total distance from bottom to top measured along the slope was 83 ft. Anchor strips of concrete, 3 ft. wide, spaced on 18-ft. centres, were first constructed from bottom to top of slopes. These strips were placed by usual methods, using 12-in. x 12-in. timbers on each side set to line and grade to retain the concrete which was likewise held in place by wooden panel forms.

At the beginning of operations it was planned to fill the intervening spaces by using wooden panel forms secured to these strips by anchor bolts. This method was pursued during the earliest stage of construction. By means of heavy scantling walings laid over and bolted down to each of the lower panel forms, the form work was gradually carried up the slope using the concrete previously placed below and the strips at each end for anchorage. A number of the 15-ft. spaces were thus filled successfully from bottom to top of the slope; but after this system had been in use for a short time it was evident that its continuation would result either in very slow progress, or in a very great increase in the number of forms required and a corresponding addition to the working force. Several alternative methods were worked up in the drafting office, resulting in the development of an idea, suggested by the foreman in charge of the work and elaborated by the superintendent, upon which was based the system eventually adopted for the completion of the balance of the work.

In the local shops of the Commission a frame, 16 ft. wide and 17 ft. high, was fashioned of 9-in. channels, and sixteen 9-in. channels were rivetted parallel to the bottom of the frame at intervals of one foot to the inner side of the frame and struts; ¼-in. steel plates were securely fastened with countersunk rivets. The outer side was braced with 4-in. x 4-in. steel angles between the diagonally opposite corners. To one end was fixed a yoke consisting of bent channels with a shackle at the centre. Thus was built up a panel of structural steel which, together with a small hand winch, an eight-part ⅜-in. steel cable and falls, constituted one of the units of the system of movable forms.

The use of the wooden panels already in service was discontinued on the upper portion of the slopes and these panels were brought forward to construct the lowest 18 ft. of the slope in advance of the movable forms. This expedient was economical and afforded means of working concrete behind the forms in 3-ft. lifts, which would have been impracticable behind the steel forms. A standard movable form was then lowered to the bottom of the slope and drawn up by means of the winch until the top edge of the form projected about a foot beyond the end of the concrete, placed by the wooden panels. The form was then in position for use. Power for the winch was supplied by two men and was quite sufficient to provide, by means of the eight-part fall, the required slow motion for the form in sliding.

The plant for supplying concrete was of the stationary type and capable of furnishing upwards of 60,000 cu. yds. in a season. About one-quarter of its capacity was required for concreting the slopes herein described. It consisted of an elevated trestle for supply of aggregates dumped from incoming cars into bins, which in turn fed the mixing machines. The mixers, of which there were three in number, each of 1-yd. capacity, discharged by gravity into cars for transportation to the point at which placing was in progress. One of these mixers discharged into a hopper which was elevated by a 180-ft. tower and delivered to a hopper on a small tower on the opposite side of the canal by means of a chute 330 ft. long, and thence was likewise taken by car to the point of discharge.

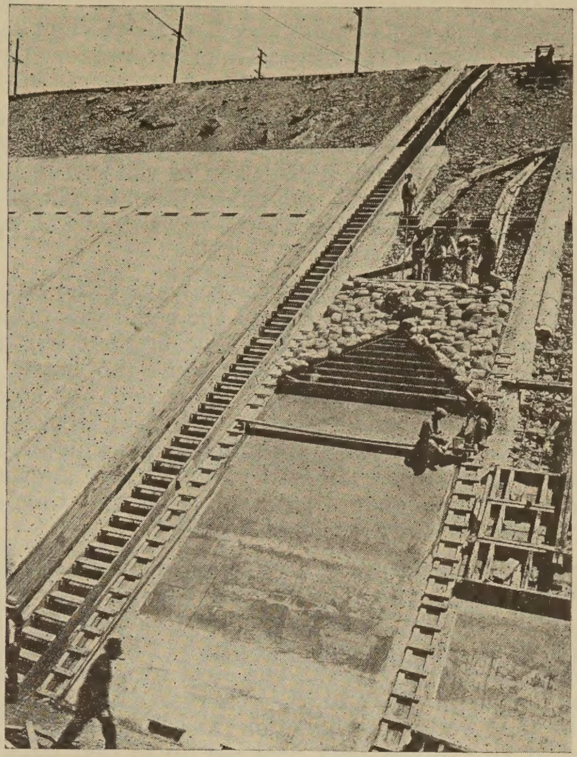

FIG. 5—CONCRETING BEHIND MOVABLE FORM. NOTE WINCH AT TOP AND PROCESS OF FINISHING. THE DIFFERENCE IN APPEARANCE BETWEEN THE LOWER PORTION POURED BEHIND WOODEN PANELS, AND THE UPPER PORTION USING STEEL FORM CAN BE DISTINGUISHED

The cars were especially made in the local shops and consisted of heavy I-beams mounted on standard gauge trucks. A steel plate platform was rivetted to the tops of the beams, which were so spaced as to afford a base for four 1-yd., rocker, concrete dump bodies. Each car was motor-driven from power supplied by overhead wires. The receptacles on the cars were so spaced that two mixers could discharge simultaneously.

At the very top of the embankment where work was in progress large portable wooden hoppers were set up, discharging into iron chuting. The chutes were usually attached to the reinforcing steel and were in short lengths, easily moved from one section to another. Each hopper was equipped with the usual gate for regulating the supply of concrete to any form and as it was customary to operate two or more adjacent panels at the same time, concrete could be diverted from one to the other at will, by throwing one of the upper lengths of chuting.

Since the weight of the movable form in itself was insufficient to prevent riding high on the anchor strips at the sides, it was ballasted with sand bags.

The rate of progress depended largely on the consistency of the concrete, and the weather conditions. Frequently a full panel length was concreted in a day, thus attaining a maximum speed of about eight feet per hour. Fresh concrete was thus covered for about two hours.

The concrete produced was extremely dense and smooth when exposed, but to avoid the disgfigurement caused by small percolation of water from the base of the form as it advanced, and to obtain a thoroughly uniform surface, the work was followed up by a finisher (Fig. 5).

The long chute employed for conveying the mixed concrete to the opposite side of the canal was placed on a minimum slope of 24°. The original mixture specified was found to be somewhat too harsh to deliver the mix intact to the lower end. A study was immediately undertaken by the field laboratory to eliminate this trouble and prevent blocking of the chute. The remedy adopted was a definite addition of sand to the standard mix, and from that time on no further difficulty was experienced.

Six movable forms were assembled for this work. The best day's run totalled over 4,000 sq. ft. The total area of the slopes amounts to 322,000 sq. ft. Concreting was commenced April 8, 1921, and completed August 31, 1921. The steel forms were first used on April 30, and the average daily progress from that date to completion was 2,566 sq. ft. as against an average daily progress up to that date of 706 sq. ft. About twelve men were sufficient to handle the concrete work for one panel apart from the mixer crew.

The concrete for this work was proportioned by the standard method, referred to elsewhere, and it may be said here that the workmen soon found it to their advantage to adhere to the prescribed mixes and to use as little water as possible consistent with concrete which would flow down the chutes. Slight additional quantities of water were found not only to impede progress but also resulted in a finished job of unsatisfactory appearance, and on one occasion, during colder weather, caused the loss of a few feet of the panel which was insufficiently set while covered by the form.

The adoption of this improved way of placing concrete on these steep slopes thus resulted in increased speed of construction, a large reduction in labor costs, a relatively small net expenditure in regard to the plant employed, and a quality of the finished work which could not have been obtained by the use of ordinary methods.

Sir Adam Beck is chairman of the Hydro-Electric Power Commission of Ontario, under the authority of which the Queenston-Chippewa Power Development was undertaken. Fred A. Gaby is chief engineer of the Commission; H. G. Acres, hydraulic engineer; T. H. Hogg, assistant hydraulic engineer, and M. V. Sauer, engineer of design. The work was carried out under the direction of Mr. Acres, with G. H. Angell as general superintendent, and the writer in charge of field engineering.

Stone Screenings as Fine Aggregate for Concrete[1]

By Duff A. Abrams
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There is probably no question in the whole category of concrete testing which raises so many knotty problems as that of the determination of the relative merits of crushed stone screenings and natural sands as fine aggregate for concrete. It brings us back to the question of what concrete is and the underlying principle on which the proportioning of mixtures is based and the many details of testing of aggregates and concrete. The methods of testing are very important features of any discussion of the relative merits of different materials in concrete. In other words, if our tests are not carried out in an absolutely comparable manner, we are almost certain to get misleading results and may arrive at entirely erroneous conclusions.

Concrete is a mixture of cement, aggregate and water. Too often the water is entirely overlooked in our discussions. We go to great lengths in testing cement and in examining aggregates, but pay no attention to the quantity of the mixing water.

Investigations carried out at the Lewis Institute in cooperation with the Portland Cement Association during the past eight or nine years have given us a great deal of new information on the underlying principles of concrete mixtures and on many related topics. These investigations have shown that the *quantity* of mixing water is by all odds the most important factor in a concrete mixture. Wide variations in the type or size and grading of aggregate and in the quantity of cement, make much less difference in the strength and other properties of the resulting concrete than do slight variations in the quantity of mixing water. This consideration of the effect of quantity of mixing water has a most important bearing on the relative merits of screenings and natural sand; if we do not get the proper balance between the water content in the mixtures, we are certain to get results which reflect that variation rather than the effect of the shape and size of the aggregate article.

The general characteristics of aggregate for concrete are: (1) structural quality, (that is, they must have a certain degree of hardness, toughness and general durability, whatever we term it, that will enable them to withstand the stresses which come upon them and to resist exposure to weather, etc.); (2) cleanness—freedom from excessive amounts of clay and dust and from organic impurities such as may occur in surface loam; (3) size and grading, depending on the mixtures used and the type of work under way; (4) shape of the particles.

The only question at issue here is the effect of shape of particles, since we must consider that the aggregates are of similar structural quality and similarly graded, or we are not working on a uniform basis. Natural sands and gravels differ from crushed rocks only in that they have been broken down and in general the particles are rounded by natural agencies. The principal agencies in the production of sand and gravel are, no doubt, glaciation, stream action and weather. Those causes will probably account for formation of sand and gravel, so that we are dealing with the same materials except that one has been rounded and the other has not.

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[1] Paper presented at the Annual Meeting of the National Crushed Stone Association, held in Chicago, January 17, 1923.

We have studied the relative merits of screenings and sands to some extent, not to as great an extent as we desire, and not to a sufficient extent to clear up all of the problems that arise.

In dealing with concrete mixtures, there is always a question as to just what quality of concrete we are trying to secure. All concrete work must be done with a consideration of durability and cost. We cannot get away from those two limitations. If concrete is not durable it will be disappointing in the end; if it costs too much we cannot afford to use it. There are also the important questions of strength, wear, water-tightness, ease of placing, ease of finishing, resistance to various destructive agencies and appearance.

So far as most of these topics are concerned, there is little room for choice between screenings and natural sand. However, when we come to such topics as water-tightness, ease of placing and ease of finishing, difficulties are sometimes encountered.

During the past three or four years we have carried out four separate series of investigations in which comparisons were made between the relative merits of natural sands and screenings. These tests apply only to the *strength* of the resulting mortar or concrete and do not constitute a complete investigation of the subject.

Series 2. This series includes tension and compression tests of 1:3 mortar at 7 and 28 days, using about 1300 different samples of fine aggregates from widely scattered sources. These samples were sent to the Laboratory for test during the period 1914 to date. For about 800 of the early samples, briquettes of 1:3 mortar by weight were tested at ages of 3, 7 and 28 days; for the remaining 500 samples, 3- x 6-in. or 2- x 4-in. mortar cylinders of 1:3 mix by weight or by volume were tested in compression at 7 and 28 days. Among these samples were a large number of stone screenings. Due to the fact that these tests extended over a long period of time, it was our practice to make parallel tests using standard Ottawa sand on each day that other fine aggregates were tested.

It is impracticable to give all the details of these tests in this report; however, the principal conclusions, so far as our present inquiry is concerned, may be summarized as follows:

1. The amount of mixing water used and the manipulation of the mortar may affect the strength more than the grading or type of the aggregate used.
2. For mortars of similar consistency, the strength varied with the grading of the aggregate as measured by fineness modulus. The higher the fineness modulus (coarser the grading) within certain limits, the higher the strength.
3. Other conditions being equal, aggregates of same fineness modulus gave about the same mortar strength at 7 and 28 days.
4. In general, screenings are graded coarser than the average natural sands; hence, if the grading is not taken into account, the screenings will generally be found to give higher *mortar* strength than sands.
5. Mortar strength tests do not give definite information on the relative value of sand and screenings for *concrete* mixtures. There appear to be two reasons for this result: (a) The angularity of the particles in the screenings permits more tamping and consequently probably receives more in the molding of the test pieces, than the sand. (b) In 1:3 mortars the screenings of sand constitute the *whole* aggregate, while in concrete mixtures these materials are only about ⅓ the aggregate, hence their influence on the final result is much less in concrete than on mortar mixtures. In the case of briquette tests, there is an additional reason for discrepancies in that the shape of the specimen and the resulting distribution of stresses give results entirely different from that found in compression tests of concrete. (This conclusion was reinforced by later series of tests described below.)

Series 84. Compression tests were made on 6- x 12-in. concrete cylinders at ages of 28 days and 6 months. Mix 1:5 by volume, relative consistency 1.00, (normal consistency). In this series the fine aggregates were limestone screenings and natural sand and the coarse aggregates crushed limestone and pebbles. Four combinations were used as follows: sand and pebbles, sand and crushed limestone, limestone screenings and pebbles, and limestone screenings and limestone. Twenty-seven different gradings of each of the above combinations were used. The size of the fine aggregates varied from 0 to No. 48 and 0 to No. 4; the coarse aggregate was of the same grading throughout and ranged from No. 4 to 1¼-in.

In order to secure a uniform grading, all aggregates were screened into several sizes and recombined by weight. The sand was largely of limestone origin from Elgin, Ill. As produced for the market, this sand is well-graded up to about ¼-in. and is a high-grade concrete sand, known in the trade as "torpedo". The consistency of the concrete was judged by an experienced operator. A total of 432 concrete cylinders was tested.

Fig. 4 shows average relation between the grading of the aggregates, as measured by fineness modulus, and the compressive strength of the concrete at 28 days, for the gradings employed in this series. The fineness modulus is a measure of the size and grading of the aggregates; it is the summation of the percentages coarser than each of the following sieves: 100, 50, 30, 16, 8, 4, ⅜, ¾ and 1½ in., divided by 100. Aggregates in which the coarser particles predominate have a high fineness modulus and those in which the finer particles predominate have a low fineness modulus.

These tests show that the concrete made with natural sand and pebbles gave about the same strength as that from sand and crushed limestone. The concrete made with limestone screenings as fine aggregate gave considerably lower strengths. The lowest strengths were obtained with the screenings as fine aggregate and pebbles as coarse aggregate; the strength of concrete was about ⅔ of that from sand as fine aggregate and pebbles or crushed limestone as coarse aggregate. The screenings required about 30% more water for normal consistency than was necessary with sand; this increase in mixing water would be expected to produce about the reduction in strength indicated.

Series 145 (A). This series included tests of mortar and concrete made from about 200 samples of fine aggregates obtained from various parts of the United States and Canada, among which were natural sands, screenings from limestone, granite, trap, slag, chatts and other materials. Tension tests of briquettes of 1:3 mortar (by weight) and compression tests of 2-in. x 4-in. cylinders of 1:3 mortars (by weight and by volume) were made at ages of 7 and 28 days, 3 months and 1 year. Compression tests of 1:4 concrete in the form of 6-in. x 12-in. concrete cylinders were made at the same ages; wear tests of 8-in. x 8-in. x 5-in. blocks were made at 3 months. The coarse aggregate was pebbles graded from No. 4 sieve to 1½-in. from Elgin, Ill. The relative consistency was 1.10. This investigation included about 3800 briquettes, 7600 2-in. x 4-in. cylinders, 3200 6-in.

Table I

MORTAR STRENGTH TESTS USING SAND AND SCREENINGS

The relative strength of the mortars is expressed as a ratio to the corresponding strength of standard Ottawa sand mortar of the same mix and same age.

Fine Aggregate	Number of Samples	Fineness Modulus	Water-Cement Ratio	Flow	Relative Mortar Strength			
					7d.	28d.	3 m.	1y.
Tension Tests of Standard Briquettes. 1-3 by Weight								
Sand	87	2.69	0.78	141	1.37	1.18	1.21	1.42
Limestone Screenings	11	3.14	0.80	136	1.69	1.50	1.61	1.99
Slag "	9	3.45	0.86	122	1.33	1.15	1.33	1.74
Trap "	3	3.37	0.77	125	1.89	1.70	1.79	1.99
Granite "	4	2.96	0.74	124	1.87	1.53	1.73	2.02
Chatts	10	3.62	0.71	120	2.01	1.74	1.85	2.16
Compressive Tests of 2-in. x 4-in. Cylinders. 1-3 by Weight								
Sand	87	2.69	0.78	141	1.32	1.23	1.16	1.19
Limestone Screenings	11	3.14	0.80	136	1.82	1.59	1.43	1.53
Slag "	9	3.45	0.86	122	1.22	1.10	1.08	1.20
Trap "	3	3.37	0.77	125	1.71	1.52	1.43	1.53
Granite "	4	2.96	0.74	124	1.68	1.56	1.49	1.49
Chatts	10	3.62	0.71	120	1.64	1.56	1.40	1.43
Compressive Tests of 2in. x 4in. Cylinders. 1-3 by Volume								
Sand	87	2.69	0.85	135	1.25	1.16	1.03	1.18
Limestone Screenings	11	3.14	0.92	133	1.73	1.41	1.33	1.56
Slag "	9	3.45	0.83	122	1.27	1.17	1.07	1.25
Trap "	3	3.37	0.86	125	1.48	1.43	1.19	1.41
Granite "	4	2.96	0.81	120	1.59	1.48	1.30	1.51
Chatts	10	3.62	0.76	125	1.58	1.48	1.28	1.40

x 12-in. cylinders and 1200 wear tests—a total of about 15,800 specimens.

Table I

The principal results are given in Tables 1 and 2. In the preparation of the 1:3 mortar, care was taken to use the same consistencies throughout. The consistency was judged by an experienced operator and checked by a "flow-table" similar to that used by the Bureau of Standards. Somewhat wetter consistencies were employed in these tests than for standard tests of cement in order to avoid the variation in results due to irregularly graded aggregates when mixed to a relatively dry consistency.

The natural sands and slag screenings had approximately the same average strengths at all ages and gave the lowest values of the materials tested. The stone screenings gave higher average mortar strengths than the sands; the different types of stone screenings gave essentially the same strengths. It should be noted that the average fineness modulus of the sands was smaller than that of the crushed materials, which would be expected to account for the differences in strengths. Attention should be called to the tests in Table 2, which show a different relation for the screenings when the same fine aggregates are used in concrete.

Table 2

Table 2 gives the results of strength and wear tests of 1:4 concrete using the same fine aggregates used in Table 1, combined in each case with Elgin, Ill., pebbles graded from No. 4 sieve to 1¼-in. Tests were made on 6-in. x 12-in. cylinders at ages of 7 and 28 days, 3 months and 1 year; also wear tests on 8-in. x 8-in. x 5-in. blocks at the age of 3 months. The wear tests were made in a Talbot-Jones rattler by methods described in *Bulletin 10, Wear Tests of Concrete,* of the Structural Materials Research Laboratory. The consistency of the concrete was judged by an experienced operator and checked by the flow-table. A high value of flow indicates a more plastic or workable concrete than lower values.

In order to place the different fine aggregates on the same basis in the concrete tests, the relative amounts of fine and coarse aggregate were varied in such a manner as to give a uniform fineness modulus (5.50) for the mixed aggregate; the average percentages of the fine aggregates are shown in the table.

The compressive strengths of the concretes are seen to fall into two different groups: that made of sand, granite screenings and chatts gave nearly the same strength, and that made with limestone, slag and trap screenings gave about 12% less strength at all ages. The wear at 3 months was also a little greater for the latter materials. It should be noted that a large number of natural sands was used and relatively few samples of screenings. In general more water was used with the limestone, slag and trap screenings for equal consistency than for sand, granite screenings and chatts. The use of a greater amount of mixing water accounts in part for the somewhat lower strength of the concretes made with the limestone, slag and trap screenings.

Series 145 (*B*). In order to determine the effect of mixing screenings with sand, a separate group of tests was made at the same time as *Series 145* (*A*), in which limestone, granite and slag screenings were mixed with various percentages of a well-graded sand

Table II

CONCRETE TESTS USING SAND AND SCREENINGS AS FINE AGGREGATE

Compression tests of 6-in.x12-in. cylinders.
Wear tests of 8-in.x8-in.x5-in. concrete block.
Mixed 1-4 by volume.
Coarse aggregate in all cases, Elgin, Ill. pebbles graded to 1½in. Mixed in such proportions that the total aggregates would have an equivalent grading as expressed by a uniform fineness modulus of 5.50.
Cylinders cured in a moist room until date of test; tested damp.
Wear blocks stored in moist room for 14 days; remainder of curing period in air.

Material	Fine Aggregate: Number of Samples	Fine Aggregate: Fineness Modulus m	Percent for m 5.50	Weight of Mixed Aggregate lb.per cu.ft.	Water-Cement Ratio	Flow	Compressive Strength of concrete 6 lb.per sq. in.: 7d.	28d.	3m.	1y.	Depth of Wear at 3m. (in.)
Sand	87	2.69	36	126	0.79	210	1710	3050	4160	5330	.54
Lime Scrgs.	11	3.14	41	122	0.89	198	1600	2610	3570	4680	.55
Slag Scrgs.	9	3.45	44	115	0.87	192	1330	2430	3490	4690	.59
Trap Scrgs.	3	3.37	39	123	0.92	202	1380	2430	3460	4550	.55
Granite Scrgs.	4	2.96	38	124	0.84	198	1600	2830	3970	5180	.50
Chatts	10	3.59	45	118	0.82	196	1600	2620	4050	5290	.52

from Elgin, Ill. The coarse aggregate for these tests was pebbles graded for No. 4 to 1½-in., also from Elgin, Ill. In this investigation about 500 briquettes, 1000 2-in. x 4-in. cylinders, 500 6-in. x 12-in. concrete cylinders and 100 wear blocks were tested. The results of tension and compression tests of mortars and compression tests of concrete are given in Figs. 1, 2 and 3. The wear tests are omitted from this report.

Fig. 1 shows the effect of quantity of sand in mixtures of sand and screenings on the tensile strength of 1:3 mortar. Except for the tests at 1 year there is not much change in tensile strength as the percentage of sand is increased up to 50%; beyond this point the tensile strength decreased. The mortar strength with the sand only is less than for screenings only, except in the case of the slag screenings at the later ages. In the *mortar* tests a somewhat greater strength would be expected for the screenings, since they were graded coarser than the sand. The grading of the slag screenings was quite coarse and gave rather harsh-working mixtures in the 1:3 mortar.

The results of the compression tests of the 2-in. x 4-in. mortar cylinders of 1:3 mix by weight are given in Fig. 2. In general, they show the same result as was obtained for the tension tests.

The results of the compression tests of 1:4 concrete are plotted in Fig. 3. The fine aggregates were combined with pebbles so that the resulting fineness modulus was the same in each case (5.50). The consistency of the concrete was similar, as nearly as could be judged by a skilled operator. A relative consistency of 1.10 was used. In these tests the strength of the concrete increased uniformly with increase in percentage of sand in the fine aggregate. The increase in strength for the concrete made with sand alone over that made with screenings alone was about 12% at 7 and 28 days and about 20% at 3 months and 1 year. This result is the reverse of that found in the *mortar*

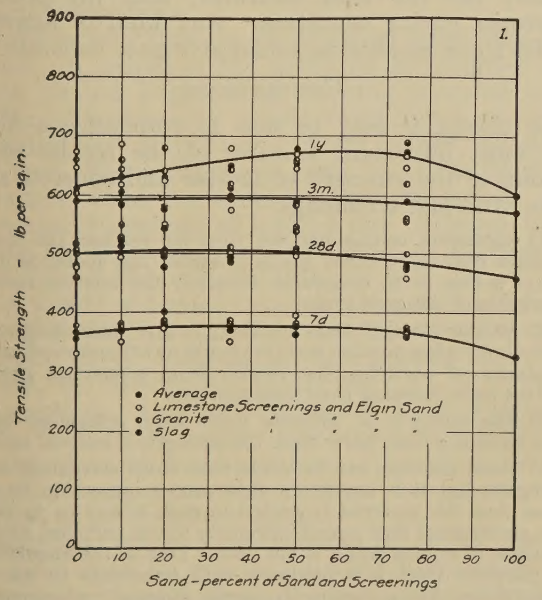

FIG. 1—EFFECT OF QUANTITY OF SAND IN MIXTURE OF SAND AND SCREENINGS ON THE TENSILE STRENGTH OF 1:3 MORTARS

Mix 1:3 by weight.
Fine aggregate; limestone, granite and slag screenings mixed with different percentages of sand.
Relative consistency 1.00.
Specimens stored in water; tested damp.

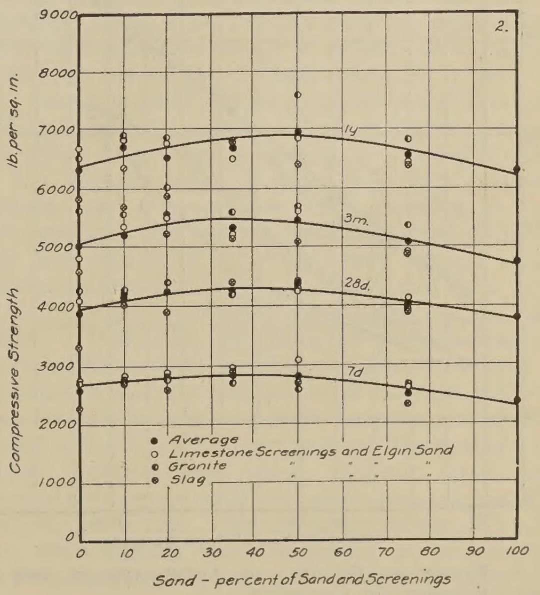

FIG. 2—EFFECT OF QUANTITY OF SAND IN MIXTURE OF SAND AND SCREENINGS ON THE COMPRESSIVE STRENGTH OF 1:3 MORTARS

Compression tests of 2- x 4-in. cylinders.
Mix 1:3 by weight.
Fine aggregate; limestone, granite and slag screenings mixed with different percentages of sand.
Relative consistency 1.00.
Specimens stored in water; tested damp.

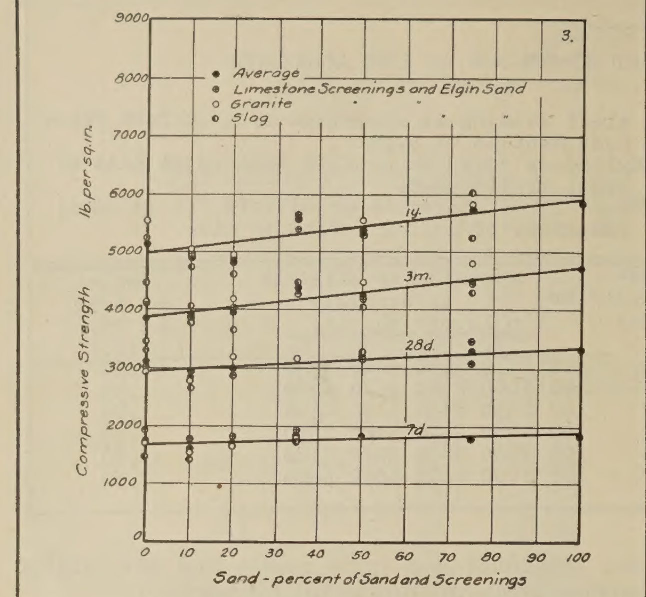

FIG. 3—EFFECT OF QUANTITY OF SAND IN MIXTURE OF SAND AND SCREENINGS AS FINE AGGREGATE IN CONCRETE

Compression tests of 6- x 12-in. concrete cylinders.

Mix 1:4 by volume.

Fine aggregate: limestone, granite and slag screenings mixed with different percentages of sand.

Coarse aggregate: pebbles graded No. 4-1½ in.

Fine and coarse aggregate combined to give fineness modulus of 5.50 for mixed aggregate.

Relative consistency 1.10.

Specimens stored in moist room; tested damp.

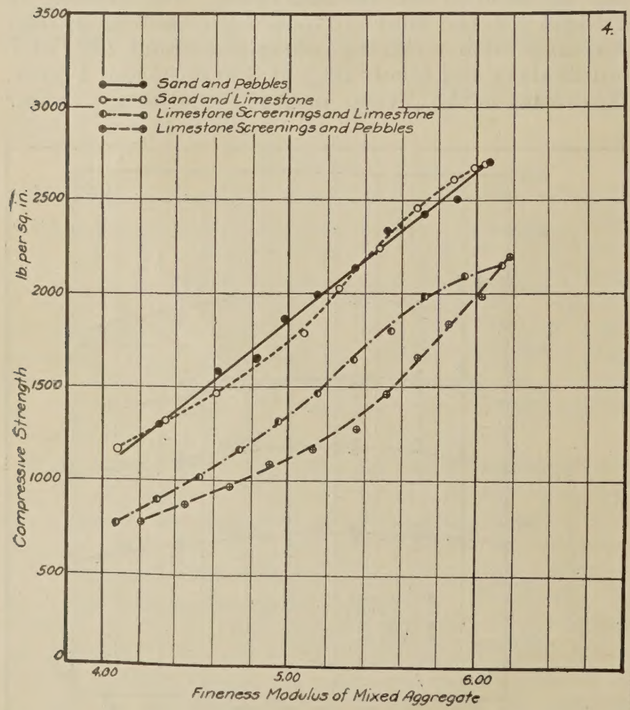

FIG. 4—EFFECT OF GRADING OF AGGREGATE ON THE COMPRESSIVE STRENGTH OF CONCRETE

Compression tests of 6- x 12-in. cylinders.

Grading of aggregate measured by the fineness modulus, as explained in the text.

Mix 1:5 by volume.

Relative consistency 1.00.

Age at test—28 days.

Aggregate graded 0-1¼ in.

Specimens stored in damp sand; tested damp.

tests and indicates that the concrete-making properties of the materials cannot be judged on the basis of mortar tests alone. A part of the difference in strength is due to the fact that the required consistency could be obtained with a somewhat smaller quantity of mixing water in the concrete made with sand.

WORKABILITY

The question which is often encountered in using screenings is the workability and ease of finishing, particularly in concrete roads. Dust in screenings in quantities up to, say 10%, does no harm, so long as the concrete is well mixed and of a proper consistency; too much mixing water causes the dust and other fine material in the concrete to float to the surface where it forms a weak, friable layer called laitance, or produces a concrete which is unable to resist wear and weather. I wish I could emphasize sufficiently the importance of a proper control of mixing water in concrete; there is no feature of concrete making that is more important. Unfortunately, we allow the mixer foreman to use his own judgment in proportioning the water in the batch. It would be just as consistent to measure the water accurately, and guess at the cement, as it is to measure the cement and guess at the water. In general we would get better results by guessing at the cement.

Care must be taken in any case in which screenings are used as fine aggregate to eliminate the quarry dirt. Dirt should not be allowed to fall into the quarry and be scooped up with the material as it is loaded and carried through the plant and into the screenings.

The writer had an opportunity to examine a concrete bridge in Nashville, Tenn., in which stone screenings were used as fine aggregate. This bridge showed very poor concrete, but it appears that the screenings have been improperly blamed for a poor job. In general, it is almost impossible to determine what was wrong with the concrete by a post-mortem examination, but in this case the poor results may be attributed to (1) sections too thin, particularly on railings; (2) screenings graded too coarse; (3) too much mixing water; (4) too lean mixtures; and (5) probably improper curing condition. Any kind of aggregate under those conditions would give poor concrete.

CONCLUSIONS

In closing it may be well to emphasize a few of the most important features of the results of our studies of the strength of mortar and concrete made from sand and screenings.

(1) Aggregate testing has not thus far reached the state of an exact science; in other words available test methods do not always enable us to determine definitely the relative merits of aggregates of different types.

(2) Mortar strength tests are likely to give misleading results, particularly when tension tests are made on briquettes; due to the angularity of particles, the mortar from screenings probably receives more tamping than sand-mortars.

(3) The strength of concrete made from screenings on the same basis is a little lower than the strength of natural sands.

(4) Good concrete can be made with stone screenings as fine aggregate, but it is important that proper inspection be given to see that the material is graded in such a way as to be free from an excess of dust and of extremely coarse particles, and that an excess of mixing water is not used. Due to the angularity of the particles there is a tendency with screenings to use more mixing water than is required by sands; especially where concrete is distributed by chutes.

(5) These tests and other investigations show that *good concrete* can be made from inferior aggregates, if proper proportions and manipulation are employed; on the other hand *very inferior* concrete may result with the best of aggregates if improper methods are used. The quantity of mixing water is the most important feature of a concrete mix.

(6) Additional studies are desirable in order to bring out the features of the relative merits of sands and screenings.

Building Code Requirements for Allowable Floor Loads

By Ira H. Woolson
Chairman Building Code Committee of the
Department of Commerce

The following article, based upon a study made by C. T. Coley, M. E., manager of the Equitable Building, New York city, describes a survey made of existing floor load conditions in that building and is the most complete study of its kind of which I have knowledge. The work was undertaken at the request of the Building Code Committee of the U. S. Department of Commerce. The efficient thoroughness with which this work was done is plainly evident, and the committee is highly appreciative of Mr. Coley's splendid cooperation.

The committee has received numerous requests that it use its influence to standardize building code requirements for allowable floor loads in all ordinary occupancies, complaint being freely made that existing requirements are widely variant, even in cities near each other. These variations result in annoyance and confusion to architects and engineers, and, so far as such requirements are unduly severe, they waste material and uselessly increase building costs.

The committee desires to comply with these requests, and to this end is endeavoring to secure all possible information of actual floor load analyses or calculations upon every kind of occupancy, except that for private dwellings, which is of minor importance and has already been treated in the first report of the committee dealing with Minimum Requirements for Small Dwellings.

There is very little to be found in print upon the subject. A search of the Libraries of Congress and of the United Engineering Societies revealed practically nothing upon the weight of ordinary commercial or industrial occupancy, except some excellent studies of office occupancies made by C. H. Blackall, of Boston, which are summarized in the article, and an extensive analysis of loading due to motor truck storage by E. L. Verveer, published in *Engineering News-Record*, February 9, 1922.

The weight of human beings in congested and freely moving masses has also been quite well determined by Prof. L. J. Johnson in this country and Mr. Kernot, of Melbourne, Australia. C. J. Tilden, (*Transactions, American Society of Civil Engineers*, 1913), also made rather extensive studies of the impulse effect of moving masses of people in sitting, rising, and rapid movement from one position to another, as on bridges or boats.

Doubtless many investigations of floor loading have been made for private purposes in various classes of occupancy, and if copies of these could be obtained for Secretary Hoover's committee they would be of real service in its work.

Office building loadings are fairly well covered by the facts now possessed, though additional information would, of course, always be welcome and helpful. We are, however, very greatly in need of data on loading in schools, churches, hotels, assembly halls, theatres, hospitals, workshops, factories, printing establishments, machine shops, public garages, etc. If a person has any floor load studies and has not the opportunity to have the work duplicated, but would be willing to loan the material to the committee, it would be very gladly received and promptly returned after being summarized. It is also hoped that this appeal may stimulate others to make similar surveys in some of the above named occupancies for the aid of the committee.

It must be remembered that such contributions are the only possible way the committee can secure the much needed material. As all the committee members are giving voluntary service to the work, which is intended for public benefit, they feel justified in urging such generous cooperative assistance as will permit logical recommendations to be deduced from well established facts, and which can be presented in a form sufficiently conclusive of their correctness to warrant general adoption as standard floor load requirements for various types of buildings.

Live Loads in Office Buildings

During the latter part of 1922, a detailed investigation was made of live loads on several floors of the Equitable Building in New York city. This structure is well known as perhaps the largest office building in the world, and the varied nature of its occupancy made observations possible which should be very useful in the design of future office buildings and proper regulation of those already in use. The study was instigated by the Department of Commerce Building Code Committee, which is investigating the possibilities of greater economy in structural design, and the objects were to determine the maximum, minimum and average floor loads existing in actual office practice; the nature and distribution of such loads; and the relations which they should bear to the assumptions for design of floor slabs, floor beams and columns as governed by prevailing building code practice. With this in mind it was necessary to determine the actual weights of office furniture and merchandise, also its location with reference to partitions and floor beams. In order to cover a wide range of usual office building occupancies, three floors were selected, representing light, medium and heavy classes of occupancy, and the entire area of these three floors was surveyed. Several other offices on various floors, representing what appeared to be unusually heavy occupancy, also were investigated. The whole survey covered over 200 rooms.

The investigation was planned and supervised by C. T. Coley, M. E., manager of the building. A force of five men equipped with platform scales and field book spent several days weighing and tabulating every article of furniture within the areas mentioned. Sketches were prepared for each office, showing the location and weights of all articles of furniture, so that the distribution of loads could be quite closely determined. Figures 1, 2 and 3 are typical examples of these sketches.

The results form a most interesting and valuable collection of data and are believed to be of much significance both to the designers of office buildings and for the purpose of determining proper building code requirements.

Following is a brief tabulation showing the outstanding features of the report on this study; Fig. 4 also summarizes the observations graphically. It will be noted that little difference exists in the average loading of the floor selected as the heaviest in the building and that which appeared at first glance the lightest.

Maximum, Minimum and Average Live Loads in Equitable Building

	No. of Offices	Maximum lbs. sq. ft.	Minimum lbs. sq. ft.	Average lbs. sq. ft.
Light occupancy floor (20th)	67	55.4	.87	10.26
Medium occupancy floor (37th)	64	30.73	3.27	10.67
Heavy occupancy floor (11th)	62	33.84	5.00	13.96
Total and Average	193			11.6
Selected heavy occupancies throughout building	14	78.3	21.4	42.4

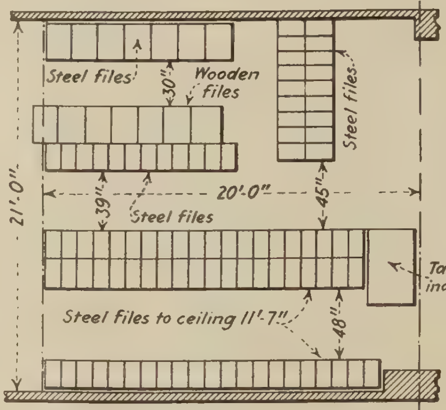

Fig. 1—File Room of Bonding Company
Summary of Loads

	Floor Covering, Linoleum	630 lbs.
2178	File drawers, 10 lbs. each	21,780 lbs.
	Racks for same	4,300 lbs.
2	Card cabinets, 100 & 300 lbs.	400 lbs.
6	Card cabinets, 50 lbs. each	300 lbs.
1	Flat top desk	200 lbs.
7	Steel file cabinets, 340 lbs. each	2,380 lbs.
7	Steel file cabinets, 200 lbs. each	1,400 lbs.
5	Wooden file cabinets, 250 lbs. each	1,250 lbs.
5	Step ladders, 50 lbs. each	250 lbs.
		32,890 lbs. Total

Total floor area—420 sq. ft.
Load per sq. ft.—78.3 lbs.

The weights given do not include the radiators, which averaged 200 lbs. each, with two to each bay, located under the windows. These would add approxmately 1 lb. per sq. ft. for all exterior bays.

The weight of the partitions was not included in the calculations. These in general are 3-in. hollow tile plastered each side, and a careful weighing of one which was being removed showed a weight of 30 lbs. per sq. ft. or approximately 350 lbs. per running foot.

The weight of occupants, taken at 150 lbs. per person, is probably high, as a considerable portion of such occupants is women, and some studies indicate that their average weight would not exceed 120 lbs.

Discussion of Results

The careful sketches of load arrangement made it possible to throw some light on the prevailing method of assuming uniformly distributed live loads as a basis for floor design, and help to indicate what relation such assumptions should bear to actual total loads.

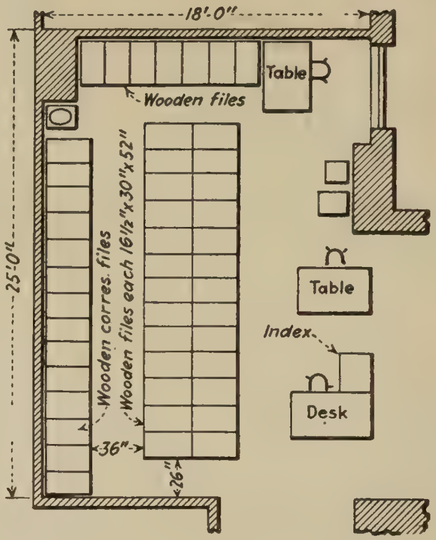

Fig. 2—File Room of Electric Company
Summary of Loads

	Floor covering, Linoleum	675 lbs.
47	File cabinets, 300 lbs. each	14,100 lbs.
2	Tables @ 150 & 100 lbs.	250 lbs.
1	Desk	200 lbs.
1	Stand	25 lbs.
1	Water Cooler	90 lbs.
2	Chairs @ 35 lbs. each	70 lbs.
3	Persons @ 150 lbs. each	450 lbs.
		15,860 lbs. Total

Total floor area—450 sq. ft.
Load per sq. ft.—35.2 lbs.

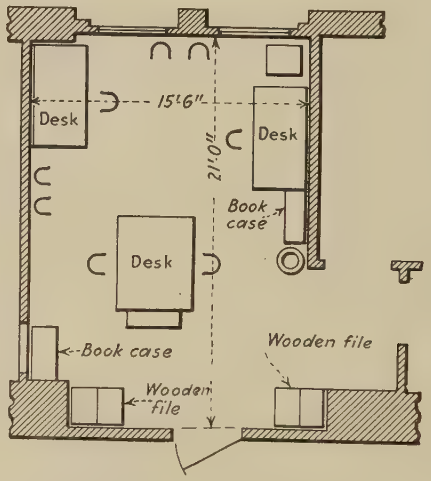

Fig. 3—Office of Electric Company
Summary of Loads

	Floor covering, Linoleum	488 lbs.
3	Flat top desks @ 400 lbs. each	1,200 lbs.
8	Chairs, 3 swivel @ 35 lbs. 5 arm @ 25 lbs.	230 lbs.
2	Bookcases @ 440 lbs. each	880 lbs.
4	File cases @ 273 lbs. each	1,092 lbs.
2	Stands @ 25 lbs. each	50 lbs.
1	Hat tree @ 18 lbs., cuspidors & baskets 30 lbs.	48 lbs.
7	Persons @ 150 lbs. each	1,050 lbs.
1	Water Cooler	90 lbs.
		5,128 lbs. Total

Total floor area—325 sq. ft.
Load per sq. ft.—15.5 lbs.

Examination of bays for which the live load was more than 25 lbs. per sq. ft., showed wide variation in the distribution of such loads. The larger proportion was found, as might be expected, within a zone approximately 3 ft. wide around the walls, the remainder being distributed variously in the centers of the rooms. In one or two cases, however, the major proportion of all the load was situated away

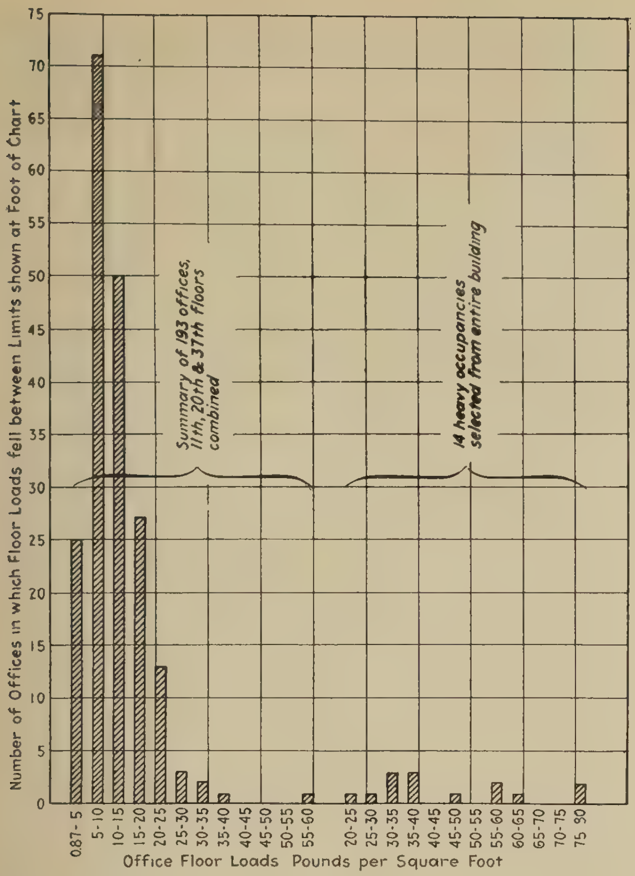

Fig. 4—Live Floor Loads in Offices from Investigation in Equitable Building, New York City

from the walls and this condition must be provided for by designers. There is also the probability that practically all furniture may be collected in the central portion of a floor area when occupants are moving, or when painting or cleaning is in progress.

The sketches show that the heavier loads, such as library shelves and double filing cabinets, are likely to be located away from the walls and partitions. This is obviously for ease of access, and the same consideration demands that when the concentrated loads per sq. ft. are excessive, generous unloaded floor areas should be provided adjacent to the concentrations so as to assure a safe distribution.

Among the heaviest occupancies found is the stack room of a large law library. The entire floor area is covered with rows of steel stacks placed back to back with 32-in. aisle space between rows, and extending from floor to ceiling, the story height being 11 ft. 7 in. There is a main aisle 4 ft. wide crossing the middle of the room at right angles to the stack rows. The total weight was taken as found and consisted of the following:

556 shelves of books @ 75 lbs.	41700 lbs.
114 empty shelves @ 25 lbs.	2850 lbs.
Books on floor	500 lbs.
7 ladders	100 lbs.
2 persons @ 150 lbs.	300 lbs.
	45450 lbs.

Area 588 square feet.
Load per square foot 77.3 lbs.

It is evident that the possibility of all shelves being filled should be considered, and, if this were assumed, the average loading would be increased to 87 lbs. per sq. ft.

Examination of all the floor sketches shows but eight articles of furniture (safes) over 2000 lbs. in weight. A number of sectional filing cases and bookcases with contents weighed much more, but these weights were distributed over such a large area they could not be regarded as concentrated. Of 36 safes and safe cabinets, 23 weighed less than 1000 lbs.; 5 between 1000 and 2000 lbs.; 2 weighed 2200 lbs.; 2 weighed 2360 lbs.; 1 weighed 2800 lbs.; 1 weighed 3000 lbs.; 1 weighed 3500 lbs.; and 1 weighed 4250 lbs.

This seems to indicate that if care in regulation of occupancies were exercised, considerable economies might be possible in providing for concentrated loads. To what extent such regulation is practical is a matter for deliberation.

As would naturally be expected, the live loads were found lighter next the outside walls. Single row filing cases, cabinets, safes, bookcases and bins are usually located against blank interior walls. Whether by accident or otherwise, the heavier loads were not found where partitions cut up the floor space into small rooms, indicating that allowance may not be necessary both for removable partitions and heavy floor loads.

Several instances were found where two adjacent floor bays supported average loads of 25 lbs. or more, but in no case were two adjacent bays found in excess of an average of 40 lbs. per sq. ft.

There are but two or three instances in the floor plans discussed where three offices or store rooms meet at the same column and it is probable that this condition will be found but rarely in buildings designed for a sufficiency of light and ventilation. In view of this and of the surprisingly light average floor loads discovered, it becomes an interesting question whether in a building of this type further reductions in loads assumed for column design could be made with safety. The building was designed for a live load of 100 lbs. per sq. ft. on the first floor and 75 lbs. on all others.

A less exhaustive but nevertheless interesting investigation of office floor loading was recently made for the committee by Capt. M. W. McIntyre, manager of the Union Central Life Insurance Company's Building in Cincinnati. This study included several large sections of different stories devoted to clerical and filing purposes. Each individual piece of furniture was not weighed but the average weight of representative articles was carefully ascertained and this result applied to furnishings of four floors.

All files, desks, etc., were considered as being 100% full or furnished with all necessary accessories. Following are tabulated the results of Captain McIntyre's investigations:

	No. Square Feet	No. pieces of Furniture	Total Wt. of Furniture	Weight of Furniture per sq. ft.
Section A	10339	635	104478 lbs.	10.05 lbs.
Section B	9303	637	27085 lbs.	2.91 lbs.
Section C	7348	273	36306 lbs.	4.92 lbs.
Section D	10339	702	121388 lbs.	11.74 lbs.
Average	9332	561.5	72314 lbs.	7.405 lbs.

Weight of employes computed at the rate of 150 lbs. each, added from .9 to 1.75 lbs. per sq. ft. of floor area.

Seven individual offices similarly surveyed showed an average weight of furniture of 7.66 lbs. per sq. ft. This building incidentally was designed to carry a live load as follows:

Basement and first floor	100 lbs. per sq. ft.
Stairways and corridors	75 lbs. per sq. ft.
Other floors	50 lbs. per sq. ft.

The committee has investigated the live loading in a reference room of a New York insurance company equipped with heavy steel filing cases for large Sanborn Insurance Map books. This was considered to represent unusually heavy occupancy. The cases were placed back to back and occupied a floor space approximately 5 ft. x 22 ft. and were 55 in. high. It was found that the case with its aisles for access occupied a space of 247 sq. ft. and weighed with contents 10,620 lbs. Observation showed it liable to use by no more than 12 men simultaneously. The total load thus occasioned amounted to 50.3 lbs. per sq. ft.

Mr. C. H. Blackall, a prominent architect of Boston, Mass., and Mr. Arthur G. Everett of the Boston Building Department, published in the *American Architect and Building News* for April 15th, 1893, the results of their investigation of three then prominent office buildings of that city.

The buildings were examined very carefully and copious notes taken of room dimensions, occupancy and details of contents. Average weights were assumed, based on averages for the various articles of furniture. The human occupancy was taken as the greatest known to have occurred in each of the offices investigated. The nature of occupancy was sufficiently diverse to be representative. Following is a resume of the results obtained:

Building	No. of Offices	Total Area in sq. ft.	Total Weight	Av. Wt. per sq. ft.
Rogers Bldg.	41	18,127	294,984 lbs.	16.8 lbs
Ames Bldg.	70	32,151	544,419 lbs.	15.6 lbs.
Adams Bldg.	99	26,183	425,109 lbs.	16.7 lbs.
			Average	16.3 lbs.

The 10 heaviest loadings in each building averaged 25.9, 29.8 and 29.0 lbs. per sq. ft., respectively. The highest load found was 40.2 lbs. per sq. ft., and in only 12.4% of the offices was the floor load in excess of 25 lbs. per sq. ft. and in only 26% did it exceed 20 lbs.

Mr. Blackall recently conducted a similar investigation of live loads in the "Little Building" of Boston which is reported in the *American Architect and Architectural Review*, January 3rd, 1923.

Sixty-four offices were surveyed, the results indicating live loads even less than those discovered in his earlier investigations. The maximum floor load was 14.7 lbs. per sq. ft. and but four offices had loadings over 10 lbs. per sq. ft. The minimum loading discovered was 1.3 lbs.

A full interpretation of the data described discloses many significant facts which space does not permit of presenting here. A detailed report on floor loads in office buildings and other occupancies will be prepared by the committee as soon as sufficient information is obtained, and recommendations for minimum floor load requirements will be made.

Mr. Blackall's data of 1893 were the only important source of information on this subject until the investigations recently completed. A few isolated observations on school floor loads have been published and the Building Code Committee has been able to obtain from private sources some additional information on other occupancies. The total is lamentably small, however, and all who can and are willing to supply reliable information of this sort are strongly urged to report it to the committee's office at the Department of Commerce in Washington, D. C.

Bonna Pressure Pipe

Reinforced concrete pressure pipes are being made in England by the Bonna system and used by the Manchester Corporation in laying another pipe line from Thirlmere, to increase Manchester's water supply, says *Concrete and Constructional Engineering.* This includes a reinforced concrete pipe between the valve-house on the Preston-Longridge road and Barnsfold Reservoir, which is approximately four miles. Work was started in November last. The pipe are being made by Messrs. Hughes and Lancaster Ltd., Westminster, with Clayton S. Sparrow in charge, under the direction of the Manchester Corporation Waterworks Engineer, L. Holmes-Lewis. Four standard types of pipe are being made.

The pipe is built up around a thin tube of steel, the standard thickness of which is 1/16 in., capable of bearing a pressure of at least 60 lb. to the sq. in. The standard pipe used on this work is 12 ft. in length with an internal diameter of 54 in., and is composed of three sheets, or sections, of steel, each of which after being accurately sheared to the correct size is rolled to the desired diameter. The edges are then butted together, and welded by the oxy-acetylene process. The three sections of tube are then welded together, thus forming one pipe 12 ft. long, and extra stiffness is obtained by affixing seams over the joints and steel collars inside the ends. The armoring of the pipe is next proceeded with, and a wooden drum 12 ft. long, provided with end pieces and trunnions so that it can be revolved, is placed inside the tube. Horizontal steel bars are laid at regular intervals along the outside of the tube and held in position until the winding over them of a cruciform spiral reinforcement. At each intersection of the armoring and the bars the two are bound with wire, so that a fairly rigid cage of steel is formed, and acetylene welding fixes it to the sheet pipe. The inner armoring is constructed in much the same way, but it is made of lighter steel, since its duty is only to support the concrete lining. This is made separately, the steel lengths being wound spirally over bars fixed horizontally to a wooden drum similar to the other. This second cage, when drawn off its support, fits inside the steel tube, to which it is afterwards welded.

The casting of the pipe necessitates the use of an outside mold and of an internal collapsible steel core. They are cast in two rows, between which is laid a light railway for the passage of a mechanical concrete mixer. When casting is being done, the armored steel cylinder is arranged vertically on a previously prepared bed, and after the inside core is inserted by the aid of a crane the external mold, usually in several pieces, is bolted round the outside armoring. The concrete, composed of Penmaenmawr granite dust and cement, is poured into the mold from the two chutes of the mechanical mixer. The concrete, after being mixed, is placed in a hopper, which tips its contents into the distributing chutes on being hoisted to the required level. During the pouring process the concrete is consolidated by prodding it with rods, and the mold and core are removed as soon as the concrete has hardened, although the finished pipes are allowed to stand for two or three weeks until sufficiently hard to be laid and jointed.

In casting the concrete, the outer coating is stopped off at each end of the pipe for a distance of some 5½ in., the steel centre being thus exposed, and when the pipes are laid and butted end to end there is, therefore, a recess 11 in. wide between the outer coverings of both pipes, the depth being 2 in. The joint is made by a steel collar, ¼ in. thick, over which is placed a steel ring, while, as a last precaution, a collar of concrete is cast over the whole joint at the time the pipes are actually laid. The strength of the joint is shown by the fact that during a test a pressure of 544 lb. per sq. in., or a head of 1,255 ft. of water, was reached, and even then the joint was not ruptured, the test being brought to an abrupt conclusion by the packing of the plunger of the hydraulic pump being blown out.

Cement Quoted by Sack

That Marquette portland cement is now quoted, sold and invoiced by the sack instead of by the barrel is announced by the Marquette Cement Manufacturing Co., Chicago.

As the announcement states, cement has for many years been shipped in sacks and used accordingly, but as a matter of custom, because it was at first shipped in barrels, quotations and purchases have always been made on a barrel basis. Believing that there is no logical reason why a product shipped and used by the sack should be quoted and sold on another unit of measurement, the Marquette company is departing from this custom and blazing another new trail for the convenience of those who handle and use its product. Instead of ordering by the barrel, as in the past, Marquette cement will be ordered by the sack, four sacks being equivalent to the old unit of one barrel.

Mixing and Delivering Concrete for City Pavements

By F. S. Besson

(Copyright 1923 by F. S. Besson)

There are three methods of mixing and delivery generally employed for concrete roadway construction: roadside proportioning, central proportioning, and central mixing. The essential difference is in the hauling. In the first, the aggregates and cement are hauled separately, stocked near the mixer at the job, and there combined. In the second, the ingredients are put together in correct proportions at a central plant and dry batches are hauled to the mixer. In the third, the wet batches are hauled from a central mixer to one or more distant jobs.

No one of these methods is suitable for all conditions. That one should be adopted which, after an analysis, shows the least cost per yard of concrete. A large expenditure for plant is not justified unless a large volume of work is done and the plant charges per unit of work are thus minimized.

Roadside Proportioning

In many cases, pavements can be built cheaper by using wheel-barrows and charging the mixer from stock piles on the subgrade, than by other methods requiring expensive equipment. For the delivery of materials special truck bodies are not required, just general utility dump trucks, and hauling does not have to be so closely coordinated with mixer operations as when either wet or dry batches are hauled. In cities, contractors mixing from the subgrade often have their hauling done by others who carry on a general trucking business. This saves the pavement contractor the large outlay that would otherwise be necessary if he had to have trucks of his own.

Storage on the subgrade of course wastes aggregate —from 5 to 10%—and adds to the work that has to be done to maintain the subgrade at the correct contour; but these are expenses that must be balanced against outlays for other equipment that would make unnecessary such storage. When motor trucks are used for hauling, care must be exercised that the subgrade is not too much cut up and rutted. After the aggregates are on the ground and mixing has started, it is generally impracticable to use a roller effectively. The distribution of materials along the line of work must be nicely balanced; otherwise, it will be found that much labor will be expended in wheeling excessive distances from the piles to the mixer. In any case, barrow charging of the mixer requires a great deal of labor; often for each barrow, one man to wheel and one to load. Since a barrow holds about 2 cu. ft., this means that with a four bag mixer there may be twenty men needed for handling sand and coarse aggregate.

Taking out time for raising and lowering the charging skip there is left, if good operating time is to be made, only 30 seconds or less for the wheelers to empty their loads into the skip. This means that for large mixers the skip should be wide enough to permit emptying two barrows simultaneously. On a few large jobs success in the replacement of men by machinery has been achieved by the use of belt conveyor loaders. For the inspector on the job, one last word of instruction is necessary: "Make sure that earth from the subgrade is not mixed with the aggregates and dumped into the mixer."

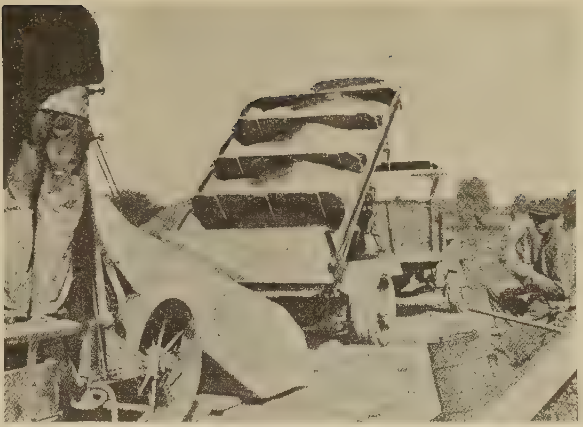

Fig. 1.—Charging Mixer with Proportioned Batches Hauled in Trucks

For the large number of small jobs that have to be done about a city, unfavorable factors connected with roadside proportioning are apt to be magnified. Separate sidewalk and alley items are seldom or never above 1,000 sq. yds. in extent, and many of them are even less than 100 sq. yds. In repair work the separate patches are very small. In the District of Columbia making 15,000 concrete repairs per year, it was found that the patches averaged but 2½ sq. yds. each. Under these conditions mixers have to be moved from place to place every few days and in addition, wheel barrows, horse-drawn carts or small trucks have to be used for delivering concrete to all those small jobs which may be considered within an economical radius of each set up. Delivery of concrete under these conditions is very expensive.

Central Proportioning

The usual equipment of a central proportioning plant consists of an unloading derrick, overhead bins and a cement warehouse. The proportioned batches are hauled to the job either in trucks with special bodies or else carried in batch boxes. In the first case the batch is dumped from the truck directly into the mixer skip, as illustrated in Fig. 1. In the latter case a mixer mounted crane lifts the boxes, dumps the batches into the skip and returns the boxes to the transporting vehicle. The delivery of materials has to be timed accurately with operations of the mixer or else much time will be lost.

By central proportioning, large economy in handling materials is possible. Aggregates are moved from the rail or water terminal directly into the mixer, and in addition it is practicable to use bulk cement which some contractors estimate means a saving of about 15 cents a barrel. On the other hand, the large outlay necessary for expensive hauling equipment needs serious consideration, especially in view of the fact that any tie-up in transportation throws the entire mixer and paving force into costly idleness.

Central Mixing

Central mixing presents many problems similar to those of central proportioning. It requires close coordination of transportation, and extreme carefulness as to the quality of the concrete. Segregation (separation of the aggregate from the other components) is one of the most troublesome factors in transporting wet concrete. When an attempt is made to remedy this by furnishing a drier mixture the concrete is often not workable and cannot be brought properly to a finished surface. Another point to be considered is that the weight of the water in the mixed concrete adds to the cost of hauling compared with the cost of dry batch haulage.

Concrete has been hauled successfully six and seven miles. Some engineers set the economic limit at a one-hour haul. Whether or not any particular mixture can be satisfactorily hauled cannot be determined by the slump test. Only by actually trying out several batches can a safe and practicable determination be made as to the degree of segregation that will take place en route and whether or not the concrete will be workable upon arrival at its destination.

Much can still be learned about constructing pavements by the central mixing method and it is not surprising that some of those who have tried this method have failed. Undoubtedly, large economies are possible: in the handling of the aggregates, by the use of bulk cement, and in the preservation of the subgrade contour. A central mixer should be particularly adapted to city work where the concreting to be done comprises a great many small repair jobs as well as a number of small street and alley paving items, all of which, while scattered, may be grouped about a central point within satisfactory hauling distance.

In the District of Columbia approximately 15,000 cu. yds. of concrete, the equivalent of 90,000 sq. yds. of 6-in. pavement, are used yearly on small work of the nature just described, and because of the difficulty of handling such work by contract it is done by city employees and plant. The high cost of doing this work by roadside proportioning methods well justified extensive investigation of central mixing. In addition, such an investigation was called for in order to decide whether or not contractors would be permitted to use trucks with 45° hoists, as illustrated in Fig. 2, for the construction of concrete base by the central mixing method.

It may be noticed that the concrete in the trucks shown in Fig. 2 did not flatten out, but remained heaped in the bodies after having travelled several miles. Since a base does not have to be given the smooth wearing surface finish of a one-course pavement, the concrete may be relatively dry, but it should not be so dry as to give a mealy mixture that cannot be properly compacted. When this is the case more water must be used, though the contractor is compelled thereby to substitute other body equipment on his trucks, or even to give up entirely the central mixing method.

Using concrete no wetter than would dump from trucks with 45° hoists (no slump by the cone test), three mixtures were investigated: 1:2:5, 1:3:6, and 1:3:7, using Potomac river ¼-in. sand and 1½-in. gravel. To determine what improvement would result if more water were used in the concrete, boxes 4 ft. square and 6 in. deep were filled with the mixture as dumped from the trucks and then tamped in the same manner as habitually used on the roadways.

These definite amounts of concrete were then mixed with additional water so as to give a cone test slump of from ½ to 1 in., and then the concrete again tamped in the boxes, expending no more labor than in the first instance. It was found that though from ⅓ to ½ gal. of water per cu. ft. of concrete had been added the boxes lacked being full by ½ in. This means that the use of dry mealy mixtures that cannot be easily compacted holds out for the contractor approximately 8 per cent of the materials that should be in the pavement. Moreover, such concrete is not nearly so strong as if it were properly compacted. For instance, a cubic foot of this dry concrete should really be compacted to 0.92 cu. ft., since the excessive voids amount to 8 per cent. For a 1:2:5 mixture, 0.92 cu. ft. of concrete of such compaction as can easily be obtained with a consistency represented by a slump of from ½ to 1 in., contains 15.3 lbs. cement, occupying 0.218 cu. ft. of space; that is, 70 lbs. cement per cu. ft. of space occupied; corresponding to a compressive strength of 2,000 lbs. per sq. in. If the space is increased by 0.08 cu. ft. we have 15.3 lbs. cement, occupying 0.298 cu. ft. of space; that is, 0.515 lbs. cement per cu. ft. of space occupied; corresponding to a compressive strength of 1075 lbs. per sq. in. Thus the deficient compaction obtained because the 1:2:5 concrete is not sufficiently plastic results not only in a 92 per cent pavement as far as quantity of concrete is concerned, but the concrete has but 54 per cent of its proper strength.

As a check on the conclusions of this investigation, a number of 6 in. x 12 in. cylinders were made with the dry concrete mentioned in the preceding paragraph. The mixture was poorly tamped in half the cylinders and well puddled in the remainder. The poorly tamped ones weighed but 88 per cent as much as the puddled cylinders and show by the compression test but 40 per cent of the strength of the latter.

One point which makes handling concrete from a central plant more difficult for city work than for country roads, is the fact that machines cannot be used for bringing the concrete to a proper surface. On repair work, naturally hand methods have to be used; also on alleys and streets, due to their unsymmetrical sections and frequent intersections it is impractical to use machines for finishing. Concrete for hand methods has to be more plastic than for machine finishing.

For base construction, satisfactory work can be accomplished with Potomac river aggregates, using lean mixtures if the slump by the cone test lies between ½ and 1 in. For one-course work with rich mixtures, the slump should lie between 1 and 1½ in. In order to determine whether a central plant could meet these conditions, various mixtures, from very lean ones to very rich ones, were tried. Many different types of truck bodies were used and time consumed on the road delivering the wet batch was varied up to a limit of one hour. It was definitely determined that trucks with ordinary hoist bodies, as illustrated in Fig. 3, are unsatisfactory on account of the excessive picking and shovelling required to move the concrete. The practices of sprinkling sand in the bottoms of the trucks, sprinkling with lime, or painting the inside of the bodies with oil, in the hope of making the loads slide, are not to be recommended. Gravity dump bodies as illustrated in Figs. 4 and 5 gave good results and the investigation showed that concrete can be delivered by them in condition satisfactory not only for base and one-course roadway construction, but also for one-course sidewalk.

Compression tests showed that concrete after a one-hour haul was equal in strength to that produced by roadside mixers. Consistency was measured by the cone test at the mixer upon loading the trucks and again on the job as the loads were dumped, and a considerable decrease in "slump" was found. On work of this nature care has to be exercised when a load is dumped, in order to be sure that representative specimens are obtained for the compression and cone tests. While segregation that may take place en route may not be sufficient to interfere with good pavement construction, it may be enough to give erratic test results unless care is taken to obtain average samples.

In order to deliver concrete of a definite consistency, it must contain excess water when sent out from the plant; the excess is to compensate for drying out en route, and its amount depends upon the nature of the aggregates and their proportions, upon climatic conditions and upon the length of haul. There is, however, a limit to the excess water that may be used because beyond a certain amount it will be found that shortly after the truck leaves the plant segregation of the water takes place, and the greater the amount of excess water the quicker it comes to the top and the drier the concrete underneath appears to be. Upon dumping the load, this water, carrying some cement with it, flows off the top of the concrete and is wasted into the subgrade. The concrete underneath cakes in the truck so that it is with difficulty taken out and then gives an unsatisfactory surface finish.

Using Potomac river aggregates with mixtures richer than 1:2:4, it was found that a slump of 3½ in. could be used as marking the limit of excess water beyond which it was not well to pass. Slumps of from 2½ to 3 in. gave good results after a one-hour haul. With these slumps there would be some segregation, that is, a film of mortar would show on top of the concrete, but water as distinct from mortar would not be present. Mixtures leaner than 1:2:4 could not be controlled as nicely as richer ones. With the latter, as the amount of water was increased, slumps could be obtained from 0 to 6 in., varying uniformly by small increments. With lean mixtures after a slump of about 2 in. was obtained, the addition of water caused the cone to slump quickly as much as 6 in. and the leaner the mixture the more difficult it was to measure slumps between 2 and 6 in. Thus it was found that with a lean mix and a slump of more than 2 in. water very readily came to the surface en route. However, since surface finish is not so important for base construction, it was found practicable to use mixtures not so wet as to give poor results in hauling and yet not so dry as to give poor results in constructing the pavement. The conclusion may be drawn that the central mixing method can be used successfully for general highway work about a city. There are, however, many details that have to be worked out locally and carefully controlled by the engineer.

A Central Mixing Project

To illustrate the drawing up of a project for a central plant, the following example is given, based on an average hauling distance of 4½ miles from the mixer to various small jobs distributed about the District of Columbia: The site for the plant is assumed at the water front, with electric power for operation, overhead storage and measuring boxes for aggregates, and direct discharge from the mixer into motor trucks. A No. 14-S mixer is chosen, and the plant layout is as shown in Fig. 6, the cost being as listed in the accompanying table.

ESTIMATE OF COST FOR CENTRAL MIXING PLANT

Bin				
4481.0 bd. ft. lumber	@	$130.00	$ 582.53	
17.7 cu. yds. concrete	@	30.00	531.00	
315.0 lbs. reinforcing steel	@	0.06	18.90	
248.8 lbs. structural steel	@	0.10	24.88	
474.2 lbs. bolts	@	0.30	142.26	
			$1,299.57	$1,299.57
Trestle				
1691.3 bd. ft. lumber	@	$130.00	$ 219.87	
1.0 cu. yds. concrete	@	30.00	30.00	
			$ 249.87	249.87
Mixer Platform				
6.5 cu. yds. concrete	@	$ 30.00	$ 195.00	
174.0 lbs. reinforcing steel	@	0.06	10.24	
			$ 205.24	205.24
1 Mixer (No. 14)			$1,750.00	
1 10 H. P. No. 173 A. C. hoist			810.00	
70-ft. portable track, 2 ft. gauge			49.00	
2 8-in. pulley wheels with parts, etc.			34.66	
150 lin. ft. ⅝-in. cable	@	$ .12	18.00	
1 Dump Car	@	85.00	85.00	
2 Chutes	@	30.00	60.00	
			$2,806.66	2,806.66
				$4,561.34
Plus 15% (Overhead and Contingencies)				688.66
				$5,250.00

For a modern No. 14-S mixer, an estimated output of 120 cu. yds. per day is conservative, and would take but 125 operating days per year to give a required total of 15,000 cu. yds., or 90,000 sq. yds. 6 in. thick. Since there should be little or no lost time on account of "administration," moving from job to job, and lack of materials, a plant such as this should be able to work 200 days per year and, therefore, the estimate of 125 days allows a large leeway for contingencies and also for future expansion of the output.

A three bag batch of 1:1⅝:4 proportions may be assumed to give 13 cu. ft. of mixed concrete, weighing as follows:

3 bags cement	282 lbs.
4⅞ cu. ft. sand	487 lbs.
12 cu. ft. gravel	1,200 lbs.
19 gals. water	160 lbs.
Batch Weight	2,129 lbs.

Having determined upon the No. 14 mixer as the largest size warranted by the volume of work to be done, the next question is as to the number of batches to be carried per truck. With an average haul of 4½ miles, about one truck trip per hour would be made, and the actual time loading at the mixer would be but a small portion of the truck trip time. If 10 trucks are required when carrying 3 batch loads, then practically 30 would be required if only one batch load were carried.

It is thus apparent that as many batches should be carried per truck as it is estimated can be readily handled by the men on the street. For alley, sidewalk and patching work it is considered that a three batch load is best; and this load would also do for patching, by using dual hopper bodies, so that half the load could be dumped at one locality and the remaining half at another. The purchase of no more than ten 3-ton trucks, five with single bodies and five with dual hoppers, would be warranted. On days when more would be needed the fleet would be supplemented by hired trucks. In order to employ the truck drivers' full time, keeping the trucks busy a maximum number of days in excess of the 125 required for concrete hauling, they would be used at odd times for hauling stone and other paving materials, thereby displacing a number of trucks that are at present hired.

Transportation By Truck

There have been a great number of failures among those using trucks for hauling and most of them have been due to neglecting to allow for depreciation and proper maintenance. Many operators have seemingly made money until suddenly they discovered their equipment worn out and no money set aside for replacements. Experience has shown that trucks especially equipped for the work, as well as other paving equipment, often do not make a fair number of working days per year. It is often advantageous to have hauling done by contract, thereby saving a large outlay for equipment and at the same time getting the work done more economically, since a hauling contractor, because of the general nature of his business, can find work for his trucks daily throughout the year.

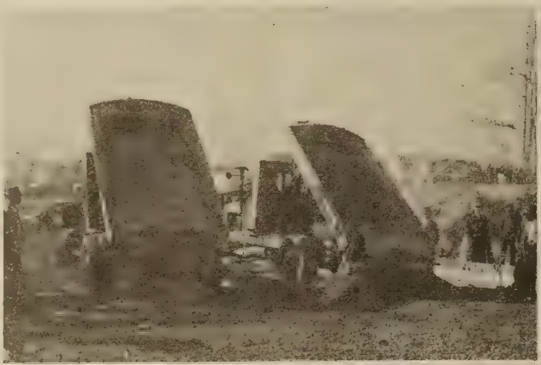

Fig. 2.—A Mixture Dry Enough to Dump Easily from Trucks With 45° Hoists Needs Careful Investigation Even for Concrete Base Construction

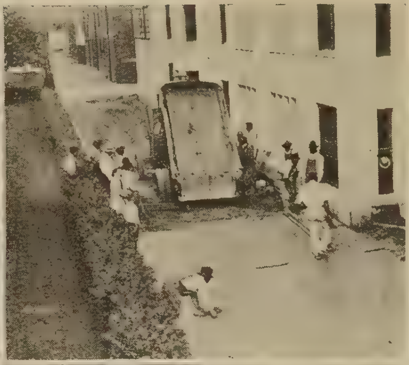

Fig. 3.—A Mix Satisfactory for One-Course Work Compacts in the Truck Body and a 45° Hoist is not Sufficient to Dump the Load

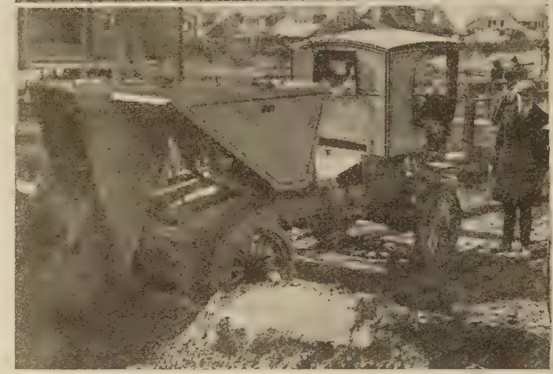

Fig. 4. — Gravity Dump Body. This Type Turns Over to Such a Degree that the Load is Instantly Released

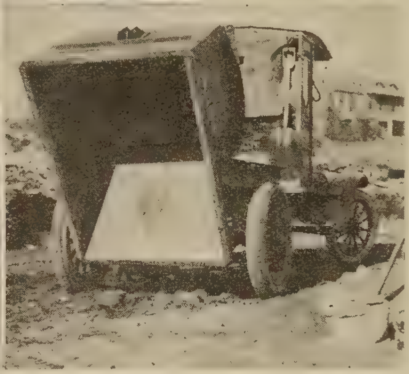

Fig. 5.—Dual Hopper Gravity Dumps

The analysis of operating costs may best be illustrated by means of an example. Assume that a 5-ton truck averages 55 miles per day, works 250 days per year (this is a high average but is attained by many hauling contractors under city conditions), and carries full loads in one direction only, returning empty; then costs may be tabulated as follows:

Drivers' Wages	$1,200.00
Depreciation (20% on $5,000)	1,000.00
Interest (6% on $5,000)	300.00
Insurance	300.00
Garage	150.00
Maintenance, minor repairs and supplies	400.00
Complete overhaul, once a year	400.00
License fees	100.00
Tires	360.00
Lubricants	90.00
Gasoline	1,200.00
Total per 250 operating days	$5,500.00
Per operating day (250 per year)	$ 22.00
Per operating mile (55 per day)	0.40
Per delivery mile (27½ per day)	0.80
Per ton, delivered one mile (5 tons per trip)	0.16

From an inspection of the table it is clear that ton-mile costs may be reduced in three primary ways: increasing the number of operating days per year, increasing the daily mileage, and carrying loads on the return trips. Many truck owners try to reduce costs by carrying 7 or 8 tons on a 5-ton truck, but in the long run this does not pay. If there is a regular field for such heavy hauling 7½-ton trucks should be purchased.

Industrial Rail and Cars

As it is necessary to keep cross streets open for traffic, industrial rail and cars find a very limited field of use in city paving work. They have been used to some small extent in order to deliver concrete from a mixer located on a side street contiguous to the one under construction. All mixing operations are thereby concentrated at one fixed spot, and aggregates are not handled on the subgrade. In reality this method gives a central mixing plant close to the job, with short haul delivery over the subgrade. Another adaptation of track and cars is the hauling of batch boxes for short distances to a mixer which deposits the concrete directly in place. In either case, trucks bring the materials over the city streets from the yards to the vicinity of the job, and the track and cars obviate hauling over the subgrade which once prepared may thus be kept in good shape.

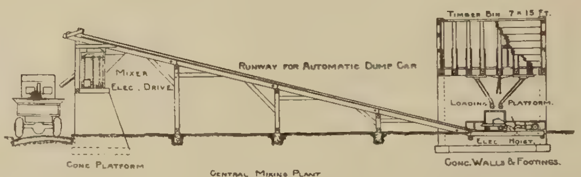

Fig. 6.—A Central Mixing Layout Using a Three Bag Mixer and Having Bin Storage for One Hour's Operation

Track generally used is portable, consisting of short sections of light rail fastened to steel channel ties. Most contractors have adopted a 2-ft. gauge. Cars are usually pushed singly by man power. The V-dump type with side height of about 3½ ft. is most popular for delivering a wet batch. They should be no larger than ¾-yd. capacity, which one man can push at a speed of about 200 ft. per minute and average throughout the day, including loading and waiting time, about 100 ft. per minute. From these data costs of delivery may be computed. Generally it will be found that 500 ft. more or less, dependent upon the wages of labor, is the maximum economical distance. For greater distances a small locomotive might be used running the cars in trains but such plant is warranted only on work of large volume and finds little or no application in cities where, as has been stated before, cross streets have to be kept open. With either locomotives or man power, difficulty is had if track is laid on grades of much more than 3%.

Trend of Highway Design[1]

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The title contains an implication which is an admission—we are not satisfied with the roads we are building. Trend means change in a certain direction, and change involves two factors: inadequacy in present results; and new conditions requiring new adaptation of means to end. The end, or purpose, of roadbuilding is transportation; the means are the vehicles on the road. The new condition arising is the great increase of motor truck traffic for the transportation of short-haul freight and of passengers. In 1917 there were in the U. S. 387,700 motor trucks; five years later, in 1922, they had increased in number to 1,250,000 or 320% plus. Motor cars, in the same period increased from 4,983,300 to 10,250,000. Under this tremendous, destructive traffic, costly roads are disintegrating. Obviously, our present roads are in many cases inadequate. What are we to do? The answer would seem simple. We can estimate with fair accuracy the future traffic over a new road. Design that road of sufficient strength to endure it! That, from an engineer's standpoint would be entirely practicable, but not from the taxpayer's to whom the cost would be prohibitive. He must steer between Scylla and Charybdis—the Scylla of demonstrably heavy enough design at too great cost, and the Charybdis of false economy in squandering labor and material upon roads that will go to pieces before they are paid for.

Our problem then which underlies the present trend of design is to plan roads that will sustain heavy traffic and yet last at least during the term for which they are bonded, repaying to the taxpayer in accrued wealth that which is spent upon them. Briefly, we are experimenting, formally at experiment stations, practically on every bit of pavement we lay, to find out how to build the best possible road at the least possible cost. Here are the results so far in respect to the concrete road, to the discussion of which my paper is limited.

Underlying the whole trend of design is the effort to oust the trial and error method by establishing scientific procedure based upon ascertained facts.

1. Fundamental to design of a road is consideration of the load it must carry. Theoretically and practically street regulation of loading is essential in order that we may know for what we are designing. Tests made at the University of Maryland, Purdue University and by the Illinois Division of Highways, give us a scientific basis for procedure by proving beyond reasonable doubt that concrete pavements will last indefinitely under repeated loads not exceeding half the modulus of rupture of the concrete.

2. A second step toward the scientific design of pavements is the plan newly adopted in Illinois and formerly tried in Arizona and California. It marks the change, based on tests and mathematical analysis, from the slab thicker in the middle and thinner at the edges to one thicker at the edges and thinner in the middle.

3. With less scientific accuracy but persistent practical development is the use of longitudinal joints in concrete slabs held together by dowels.

4. To these changes in design I would add a fourth about which there has been less discussion. With no scientific accuracy at all, but increasing in use, partly as a hope, and partly from proof in service, is reinforcement with steel. In order to overcome the weakness from cracks two methods have been followed: one, increasing the thickness of the slab; two, using steel reinforcement. Both are justified within certain limits by service conditions. From the results reported on test actions of road increased thickness has unquestionable advantage. The use of steel in these experiments has not been extensive enough to warrant drawing conclusions.

Steel has, however, been used by practical highway engineers trying to overcome that tendency to weakness in the concrete which is ascribed to lack of tensile strength. The amount used has not been based on calculated stresses but has been determined by results gained from use under service. The use of what in the design of a building floor would be reasonably adequate percents is precluded by the relatively high cost of steel in the design of a pavement. Nor are such large quantities justified in the pavement as are in the floor, for failure in the latter might result in loss of life, whereas breaking of the former causes, at worst, increased maintenance or replacement.

Reinforcements of all kinds and conditions have been tried, each highway engineer using that style and weight which is most convincing to him either as indicated by test or by service conditions, such as smooth or deformed bars, expanded metal welded or woven mesh fabrics and structural shapes or a combination of these; weights from twenty-one pounds per 100 sq. ft. to 150 pounds per 100 sq. ft. with a percent of this in corner reinforcement; dowels; across the ends; along the edges and along the center. In direction, the main members run across the slab with the secondary members at right angles or longitudinally along the pavement or vice versa. The ratio of main to secondary member may be anything chosen in the same manner as the style and weight, etc. Why are we so far at variance? Because the conditions for design are indeterminate, and because in order to design we must have some thing more than a set of variables between uncertain limits on which to predicate such a design. *First* we must know the amount, kind and method of application of loads; *second*, the physical and chemical properties of the materials in combination; *third*, the condition, permanency, and distribution of supports. The first and second of these are easily determined. Our load limits, their application, etc., have been studied as well as the physical properties of concrete under stress and fatigue. The third I will discuss later. Experience shows that cracks will come even though reinforced with much larger quantities of steel than are at present used. Service conditions, however, show a smaller number of cracks when reinforcement is used, even though uneconomical when considered in this light alone. It is certainly useful because we can by the use of steel cut down the distance between the cracks, and while the aggregate width of cracks will not be appreciably reduced, the individual openings will be proportionately smaller, so small in fact as to prevent vertical movement between adjacent parts—for the broken faces are sufficiently rough to remain interlocked. While the theory from which the above statements were evolved may be open to question as are all theories predicated on empirical formulas, actual results under service conditions bear out the result of the theory.

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[1] From a paper for Copyrighted *Proceedings*. Presented at Convention American Concrete Institute; Cincinnati, January 1923.

It is certain that after cracks are found the metal is beneficial. Its initial investment within limits is justified by the saving in maintenance and by increased life.

In addition to these four major changes, regulation of traffic, thickening of edges, dividing longitudinally, and strengthening with steel, there are many minor ones not yet sufficiently developed to make immediate discussion of them profitable.

Important to us among these minor changes is the pouring of cracks in concrete pavements with the new compound joint filler invented by the Bureau of Public Roads. It is a combination of resin, rubber and barium sulfate, promises excellent wearing qualities and does not disfigure the pavement because, being the same color as the concrete, it is barely discernible.

With the fundamental principle underlying the trend of design illustrated in these changes we must all be in thorough agreement. For engineers by grade of their profession are essentially constructive, combining the spirit of the artist and the scientist, accepting from the former the goal of Perfection, from the latter the goal of Truth. There are few of us, however commercially minded we may be, who, in designing a new road for a community do not envisage for it greater beauty of life; and not one, I think, who would not secure his vision upon a basis of established facts. But in our very eagerness to accept facts upon which to build we need to scrutinize truths which may be misleading because they are incomplete. Sponsors of such findings are usually zealous in proclaiming their limitations but even their cautions may not offset the general human tendency toward mental laziness, easily to accept them as final. I say this the more earnestly because there is a very real danger that, in taking decisive leaps, we may so discourage the production of certain materials through disuse as to prevent further experimentation along lines of their possible contribution to road building. How much the material producers have furthered our knowledge of road building is beyond calculation.

Limitation of loading sounds like easy elimination of the most important variable in our problem of calculation. Actually it is of the greatest help, but it is not final. Who has not seen a 10-ton truck with its load so placed that three-fifths of its weight comes upon a rear wheel with a defective tire? In a spring thaw on the soft subsoil, even the thickened edge of a concrete slab might crumble under it.

The shift in balance of force from middle to edges leaves still unsolved the necessary strength in the middle.

Convenient as is the building of roads in longitudinal sections, it is by no means certain yet that they will be freer from cracks, or that the dowels themselves may not become sources of destruction.

The use of steel in sufficient quantities for actual reinforcement would cost $16,000 a mile, while in smaller quantities its use is problematical in respect to quantity and in proportion of advantage gained to money spent.

These considerations lead us back to a pertinent and pointed but easily neglected paragraph in *Engineering News-Record*, pp. 54 and 57, Jan. 11, 1923.

> Development in Design—Advance in road design has been largely confined to the pavement slab. In all states there seems to be general satisfaction with the present grade cross-sections and finish. Use of standards is the prevailing custom. Very few states as general practice design roadbed for the specific project in hand or to meet the local variations in soil, drainage and location. To repeat, highway engineers appear to be satisfied with their present standard roadbed designs.

Appearances to the contrary, I think we are not satisfied with our roadbed design, and that we have not considered it nearly enough in relation to the design of the pavement slab. Realization of this, though it has had as yet no overt expression, is today I believe one of the most important factors in the trend of highway design.

Heretofore, concrete roads in general have been designed in four ways: first, by copying a specification and typical section that was under observation or had had a successful outcome; second, by modification of a partially successful type through correcting the weak points developed in service; third, by special design to meet some of the factors in the immediate problem; fourth, by a combination of all three methods. In none of these methods as far as I know has there been a serious attempt at estimating accurately the total strength of the road as the result of roadbed plus paving slab. Many tests are demonstrating the exact strength of the slab, but so far we have no accurate gauge by which to measure the bearing power of the subsoil. We have guessed at it, and designed accordingly. Many experiments are now being carried out to determine the supporting power of subsoils with varying degrees of moisture, but their results indicate such a wide range of values that we are confronted by two extremes; either we shall pay much more attention to the roadbed, or we shall pay none at all.

As far as I can ascertain the influence upon design of considering the relation between the roadbed and the paving slab is likely to develop in these two opposite directions.

In the first case, before designing a road at all, the engineers will make a much more thorough study of drainage and subsoil conditions and bearing power of the subgrade. Then we will design, not in terms of miles or even hundreds of feet as we do now, but in terms of slab units, proportioning the strength of each slab to the support it receives from the foundation. Thus, across a stretch of swampy ground the slabs might be designed 9-in. thick with steel reinforcement equal to that of a building floor founded on supports, while 200 ft. further on, up the sharp ascent of a hill, the slabs may be only 6 in. thick with slight reinforcement. The high cost of the slabs on unstable soil would be levelled down by the low cost on the firm soil until the average cost of the road would not exceed that of the so-called "average" road today, where slabs on poor soil may go to pieces because of insufficient bearing power, while slabs of the same strength on good soil are overdesigned for the demands upon them. Concrete paving slabs, no more than individuals, can follow a standardized pattern. The service to the community of both slab and individual depends upon the environment in which it finds itself. Our effort in this direction will be to find the perfect adjustment of the slab to its foundation in order to secure the needed strength. Here, then, we are seeking the closest possible relation between the design of roadbed and the design of the paving structure.

The second tendency is the opposite extreme of this, ignoring completely the mean rut in which we have been travelling. It is to leave the roadbed entirely out of consideration, and with regard for economy, devote our energy to getting a pavement structure that *per se* will sustain the demands of traffic upon it. This is the line along which Prof. Elmer Hooper of New York University has been working and he has permitted me to present to you here some of his results. I now quote from him:

"The usual percentage of steel is so small that it is readily acknowledged by most engineers to be of little value in load distribution. Its specified purpose is therefore limited to temperature resistance, bond between adjacent units to prevent vertical and horizontal separation, and strengthening of relatively weak local areas such as corners and unsupported edges. Of these only the temperature stresses seem determinate and at first thought it might appear possible to make calculations to fix the amount of steel to keep intact a predetermined length of slab. It is unfortunate, however, that when stresses develop from temperature change there is very likely to exist at the same time severe stresses from passing loads which, though not causing any increase in the resultant axial stress do cause such a distribution of it as to overburden and rupture those fibres farthest removed from the neutral axis. When the crack starts it has to continue because of the reduced area to resist. Calculations on this basis are therefore of doubtful value. To develop a pavement of positively known qualities it is necessary to make determinate the nature and condition of supports. If and when that condition is established there is no logical reason why a design may not be developed, along the same lines as a bridge or building. It would not be necessary to use such low unit stresses for calculation of a pavement unit since it would not involve serious danger to life and property in the event of failure of a unit. Use of high unit stresses would make possible this type of construction as the quantities would not compare unfavorably with those of present types. Economy would be obtained even with a higher first cost, due to certain long life, due to low maintenance on pavement proper, and due to convenience from continuity of service.

"Along this line the writer has evolved a plan of design and construction which has for its purpose to satisfy the conditions just discussed. The point of most importance is that the pavement is made up of units, each supported at three points. The supports are solid and carried below frost. Each support carries the ends of one or more adjacent units. Adjacent edges are designed to interlock to make adjoining slabs mutually supporting. It may be readily seen that with this method of support a slight settlement of one end will cause no appreciable change in designed stresses. A tentative design has been worked out in detail, with the idea of making the construction simple, uniform, and in consequence not too high in first cost to make it compare favorably with the present types and designs.

"In the plan proposed, the subgrade will carry no load though under excessive deflection there may be contact. There will, therefore, always be a sag or tendency to sag between supports, due to dead weight as well as to live load. The top surface will be always in compression and therefore not subject to crackling. The bottom will always be in tension, so reinforcing metal would logically be used in sufficient amount to develop the full compressive strength of the concrete. Since the supports may be considered as permanent, the moments and shears for given loads may be calculated, and verified by experiment if necessary, with the assurance that service conditions will not alter values. From this data the proper section of concrete as well as quantity and position of steel can be determined.

"The only reasons for the pavement to become inadequate or obsolete are undue reduction of thickness before putting on a wearing surface, or increase in the allowable loading to be carried. Beyond that there is no evident reason why the construction should not last indefinitely.

"Other ways of meeting the necessary conditions of design may be developed and in them the design will most certainly call for steel in combination with concrete, in such a manner that it will conform to the strict definition of 'Reinforced Concrete'. The essential factors for success in any plan are workability and reasonable costs. Since unit cost of steel is high compared to concrete it is necessary that there be just enough of the metal to serve the desired purpose, and no more, in order to obtain the reasonable costs."

That is Professor Hooper's contribution. It suggests, I think, one line along which very definite progress may be made. In similar devices for an independent surface structure and on the other hand in the closer relation between roadbed and pavement we shall, I believe, follow the future course of highway design.

Playground Bench of Concrete

PLAYGROUND BENCH OF CONCRETE

The bench, 12 ft. long, shown in the picture was designed by a Philadelphia architect, John T. Windrin. It is of concrete, granite finish, cast in one piece —weight about a ton—by Julius Ruoff,, Second and Butler streets, Philadelphia. It was erected at Liberties Public Playground, Sixth and Noble streets, Philadelphia. Mr. Ruoff tells how the job was done:

The bench has a radius of 14 ft. 10 in. We first secured our true curve and after finding our marks we erected a side wall of plaster of paris, supported by brick on end. We then built from plaster of paris an outside form for the back, this being on the same radii as our first process; we separated this last, from the first a distance of 3 in. Next we assembled our two parts of the arm molds (made from a full size mold of plaster of paris) adjoining the back and slab; this was sealed to the slab on both ends of the bench. This made one cavity to be filled on the top, and two deep cavities on the ends, representing the arms. The arm, back and slab were filled in, in this order, with ¼-in. and ½-in. reinforcing, over arm and back connections with the slab; the slab reinforcing ran over back and slab, making it practically continuous. This upper part was cast bottom side up. The legs were made from full size drawings and from full size actual molds of plaster of paris and molding clay.

If you have a good idea—one you have used—exchange it for a new one—tell it to CONCRETE.

An Interesting Case of Dangerous Aggregate[1]

By J. C. Pearson and G. F. Loughlin

Brief History of the Case.

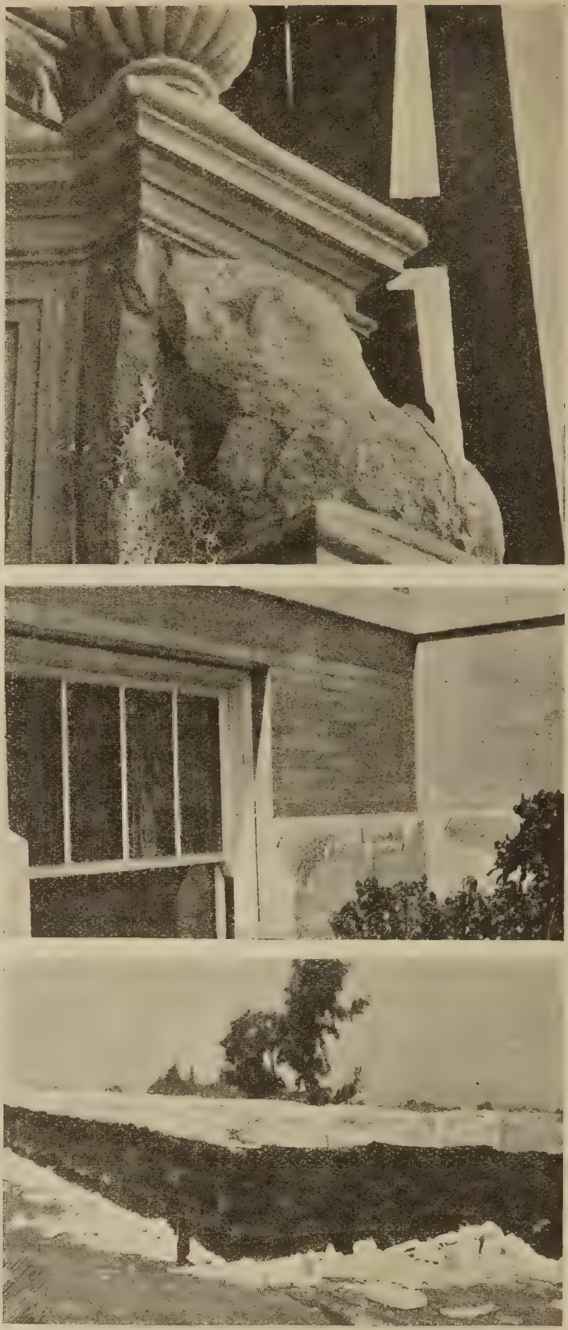
In the December, 1919, issue of Concrete, an article describing rapid disintegration of a certain ornamental cast stone and stucco in the vicinity of Los Angeles, California, was published under the title, "A Costly Experiment with Feldspar Aggregate," by Mr. Robert B. Lammens. This article attracted considerable attention from the fact that it was interpreted as a warning against the use of feldspar aggregate, although only the lime-soda variety, plagioclase, was under consideration. It is not believed that the writer of the article intended to create exactly this impression, but rather (to use his own words) "to sound a warning against the use in concrete of rock that is not very well understood".

This article naturally brought forth inquiries from users and producers of feldspar aggregate in other parts of the country, as to whether similar trouble might be generally expected from this material. The editors of Concrete endeavored to find a satisfactory answer to these questions and eventually requested of the Bureau of Standards general information on the suitability of feldspar as a concrete aggregate, and an explanation of the disintegration which had occurred in Los Angeles.

The Bureau felt that the matter was of considerable importance in view of the fact that both feldspar itself, and other aggregates of which feldspar is a constituent, have been widely used in the East, and so far as information was available, no question of durability or suitability of these aggregates had ever been raised. The question was immediately referred to the U. S. Geological Survey, however, and the opinion was obtained that in view of the known resistance of feldspar to ordinary weather exposures, the disintegration of the concrete was hardly to be accounted for in this manner.

The Bureau then asked the assistance of Mr. Lammens in the matter to the extent of furnishing all the information available and of supplying samples of the original quarry rock, the aggregate as used, and the disintegrated concrete. Promptly after his return from Europe he complied very fully with the Bureau's request, furnishing a number of samples and a complete history of the case, including an account of the physical and chemical tests that had been made prior to the marketing of the material as concrete aggregate.

Significant in Mr. Lammen's report was the fact that the preliminary tests consisted of a rough chemical analysis and the making of a few briquettes. The first sample analyzed showed 85% of SiO_2, on the basis of which the producers advertised the material as "Silica Sand". The physical tests, such as they were, compared favorably with those of other aggregates in common use. Mr. Lammens later had analyses of the material made by three different chemists, all of them classifying the material as feldspar, and one of them stating that it was *altered* plagioclase or soda-lime feldspar. To the layman, and probably to the concrete engineer also, this would not mean a great deal, but to the geologist the meaning of the word "altered" is significant. The samples of aggregate submitted by Mr. Lammens were immediately identified by the U. S. Geological Survey, not as feldspar, but as a mixture of feldspar and products resulting from the decomposition of feldspar.



Figs. 1, 2, and 3—Typical Examples of Disintegrating Art Stone in Los Angeles.

In the fall of 1920 Mr. Loughlin had an opportunity to investigate the matter on the ground, and to examine some of the deteriorated concrete structures in Los Angeles. He also visited one of the feldspar quarries. In the summer of 1922 he spent a day in a more extended visit to the country containing the feldspar deposit.

The concrete, seen in porches along Arlington Street, Los Angeles, consisted of cast blocks with cores of concrete with sand and gravel aggregate and

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[1] Abstracted from a paper presented at the Convention of the American Concrete Institute, Cincinnati, January, 1923.

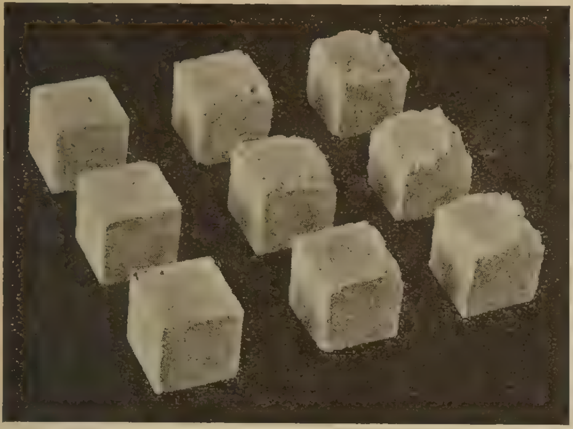

Fig. 4—Three Typical Cubes of Each of the Altered Feldspar Mixtures Tested by the Bureau of Standards After 18 Months' Exposure to the Weather

facings of concrete with the feldspar aggregate. The facings were in different states of disintegration. In the first stage cracks had formed and the whole surface had begun to break away from the core. In some blocks only a thin layer had loosened; in others the entire facing, about an inch thick, had broken away from the core, and in the most advanced stages little or none of the facing remained. The material of the broken facings readily crumbled to sand when lightly pressed by the fingers. Much of the aggregate in it had become soft and chalky. The cores of the blocks, as far as seen, were invariably in good condition. This evidence, together with Mr. Lammen's statement that the same process of disintegration had taken place no matter what brand of cement had been used, leaves no doubt that the aggregate has been the cause of the trouble.

Figs. 1, 2 and 3 show typical examples of the disintegrating art stone.

Test of Mortar Containing the Altered Feldspar Aggregate

By J. C. Pearson

It is not always that geologists are included in the staffs of commercial and other laboratories engaged in the testing of concrete materials, and it was, therefore, important to ascertain with greater certainty whether the usual physical tests of concrete fabricated from the altered-feldspar aggregate would not have shown the unsuitability of the material. To this end a considerable amount of time and money were expended to obtain some 100 lbs. of the material directly from the quarry, which could be depended upon to be truly representative of the run of the material. This shipment was received in Washington in June, 1921.

The tests were started without further delay. The rock was crushed and screened to give a similar but somewhat coarser gradation than that of the original sample submitted by Mr. Lammens. Sieve analyses of the original sample and of the material used in the tests were as follows:

Percentage Passing U. S. Standard Sieves

Number	Original Sample	Prepared Aggregate
8	100	100
16	100	71
30	85	50
50	46	30
100	19	14

Using a normal portland cement, a number of 2-in. cubes were made up in mixtures of 1:2, 1:3, and 1:4 by volume, of both medium and dry consistencies. The medium consistencies were somewhat wetter than the so-called normal mortar consistency in standard cement tests; the dry consistencies were very dry, such as to show the successive layers of mortar as tamped in the molds. It was believed that these variations would cover the range of mixtures in which the material was used commercially, but no tests were made of mixtures of other aggregates with the altered feldspar. For comparison, similar test pieces were made with standard Ottawa sand.

The test cubes were stored in the damp closet one day, in water six days, and then removed to the roof of the laboratory where they were continually exposed to the weather. These cubes were examined from time to time, and incipient checking of some of the altered-feldspar specimens was noted near the top edges within a few weeks. This did not become pronounced, however, until the spring of 1922. During the warm weather the action was very marked, and toward the end of the summer the edges of many of the cubes were falling away. A number of the cubes made from the dry mixes split at the junctions of the different layers where these occurred in filling the molds.

Generally speaking the leaner mixes show more advanced disintegration than the richer mixes. The photograph reproduced in Fig. 4 was taken January 2, 1923, and shows three typical cubes of each of the altered-feldspar mixtures after 18 months' exposure to the weather. The disintegration of these specimens seems to be in all respects similar to that of the concrete stone which occurred in southern California. It may be noted in passing that no signs of disintegration have been observed on the standard Ottawa sand specimens.

The compression tests of the cubes, which to date have been made at the 7-day, 28-day, 3-month, and 1-year periods are particularly interesting, not only because they would have given the altered-feldspar aggregate a clean bill of health at the usual 28-day period but also because the strengths have held up remarkably in spite of visible disintegration. The results of the compression tests reported in the following table are the average from three specimens:

COMPRESSION STRENGTH, LBS. PER SQ. IN., 12-IN. TUBES

Aggregate	Mix	Percent water	7-day (water)	28-day (water)	28-day (air)	3-month (air)	1-year (air)
Medium Consistency							
Feldspar.....	1:2	17.4	2320	4090	3890	4390	5490
Std. Sd.......	1:2	11.8	3090	4390	4790	5290	6570
Feldspar.....	1:3	17.4	1310	2420	2400	2590	2860
Std. Sd.......	1:3	13.1	1020	1800	1900	2030	3170
Feldspar.....	1:4	17.2	820	1460	1430	1700	1680
Std. Sd.......	1:4	13.4	630	1020	1230	1430	2280
Dry Consistency							
Feldspar.....	1:2	12.5	3080	....	5010	4970	6080(a)
Std. Sd.......	1:2	8.0	3980	....	6810	6020	6920(a)
Feldspar.....	1:3	12.5	2840	....	4570	4410	4150(a)
Std. Sd.......	1:3	7.1	1600	....	3610	3940	4430(a)
Feldspar.....	1:4	12.0	1820	....	3500	2920	3020(a)
Std. Sd.......	1:4	7.0	1250	....	3490	2600	3540

(a) These specimens were broken at 14 months.

The strength—age curves from the very dry mixes are somewhat erratic, as might be expected, but they show the same general tendencies as those from the medium mixes, which exhibit the following characteristics:

(a) The altered-feldspar aggregate gives higher strengths than the standard Ottawa sand in the leaner mixes up to and including the 3-month period. This is unquestionably an effect of the gradation of aggregate of similar gradation. In the 1:2 mixes the effect of the excess fine material in the altered-feldspar aggregate is to give lower strengths than the standard sand.

(b) The destructive effect of the altered-feldspar aggregate is becoming apparent in the 1-year tests, when the strength of the leaner mixes falls below that of the standard sand specimens. In the 1:2 mixes there is no appreciable falling off in strength of the altered-feldspar specimens up to one year.

(c) Visible and apparently considerable disintegration occurs before the strength of the altered-feldspar specimens is appreciably affected. This indicates that the deterioration starts at the surface and progresses slowly inward.

It is worth while to remark that the laboratory tests serve to show the increase in strength of the cement in newly formed concrete, but have no significance regarding the durability of the aggregate. The aggregate used disintegrates more slowly than cement hardens, but still is very rapid if measured in terms of the life of a building.

The Altered Feldspar and Cause of its Disintegration

BY G. F. LOUGHLIN

The feldspar, as stated by Mr. Lammens, is the lime-soda variety called labradorite and occurs as the principal constituent of a large mass of rock technically known as anorthosite. This formation is exposed in Soledad Canyon, about 50 miles north of Los Angeles, and has been traced from a point three-quarters of a mile east of Lang Station for about 8 miles eastward to Ravenna. On the north side of the Canyon it is overlaid by a thick deposit of gravel, sand and clay, more or less consolidated, the lower beds of which (all that were seen) consist mainly of pebbles or cobbles of the anorthosite. Near Lang these beds cover the anorthosite on both sides of the canyon. The anorthosite, which varies locally from white rock consisting almost entirely of the altered-feldspar and bluish-gray rock of unaltered feldspar to rock containing considerable quantities of dark colored minerals, forms the south slope of the canyon and extends southward for an indefinite distance. It is cut out here and there by small veins or dikes of coarse grained granite (pegmatite), and a mile and a half west of Ravenna both it and the overlying gravel are cut by a large dike of decomposed trap rock. It is one of the very few occurrences of anorthosite of appreciable size in North America. By far the largest occurrences occupy extensive areas in eastern Canada and the Adirondack Mountains of New York. I found another occurrence of appreciable, though comparatively small, size in northern Idaho in 1910, and the occurrence in Soledad Canyon is the only other of appreciable size of which I have heard.

The altered-feldspar rock, or white anorthosite, was quarried for a short time in Alpine switch 2½ miles east of Lang and also somewhere near Ravenna; but when its defective qualities became generally realized about 1913, the quarries were abandoned. Only the quarry at Alpine was visited. This quarry, from which the material used in the tests at the Bureau of Standards was collected by Mr. Boynton subsequent to our visit in 1920, is close by the railroad. It is a side hill quarry and the quarry face, about 100 ft. long, is close by a railroad siding.

The rock at and near the quarry is white to pale pink as a whole, but contains several slabs like inclusions of weathered dark rock, mica schists and hornblende. It is thoroughly shattered and along many of its fractures slight displacement or faulting has taken place. It is considerably altered along these fractures, though cores of practically unaltered rock remain in the central parts of irregular blocks.

Inspection of these cores shows them to consist essentially of coarsely granular, but thoroughly welded dark purplish or smoky feldspar—a feature characteristic of fresh lime-soda feldspar in anorthosite and related rocks. A small quantity of black mica is present and is considerably rusted by weathering. Where the black mica is unusually abundant and in relatively large flakes, it promotes weathering on prolonged exposure, but has nothing to do with the kind of weathering that took place in the concrete. Specimens of this unaltered material are most readily obtained from cobbles in the creek bed along the canyon bottom where abrasion has removed the soft altered material. Under the microscope even this material shows the effects of crushing and recrystallization, also of deep-seated alteration which has developed the secondary minerals epidote (hydrous silicate of lime, iron, and aluminum), calcite (calcium carbonate) and white mica (hydrous silicate of potassium and aluminum). These minerals form scattered grains, most of the white mica grains lying along cleavage turning and shearing planes. The calcite also forms veinlets. Where they are abundant the original dark color of the feldspar is lost, but the material is still resistant to weathering. The dark color is also destroyed by recrystallization which has resolved original large feldspar crystals into relatively fine grained aggregates. The black mica proves to be mostly altered to the green micaceous mineral, a chlorite accompanied by a minor amount of white mica. The titanium—iron oxide ilmenite, in a few small grains—is the only other conspicuous microscopic mineral.

In the chalky white to pale pink material surrounding the cores, the original texture of the rock is also lost. Where it has been exposed for some time the rock cracks into smaller and smaller fragments. Although described to me as a hard rock, it offers little resistance to the hammer and in this respect also is in marked contrast to the unweathered core. The chalky white material is partly present in distinct veinlets which range in thickness from one-eighth of an inch down to sub-microscopic dimensions. Under the microscope these veinlets form a fine network and consist of the zeolite, laumontite, accompanied in places by a little calcite. The minute feldspar fragments within the network are largely altered to a mixture of the zeolite and kaolin.

The abundance of these veinlets varies. In the rock that has lost its original dark color but retains its texture and the lustrous cleavage surfaces of feldspar, a few veinlets may be present, and all gradations from such rock to rock entirely altered to a mixture of the zeolite, kaolin and calcite in varying proportions may be expected. One specimen of a small grab sample collected from the quarry face consists mainly of calcite.

CAUSE OF DISINTEGRATION

The three minerals responsible for the disintegration are laumontite, kaolin, and to a very minor degree, calcite. The fact that aggregates of limestone and marble which consist essentially of calcite in concrete have given general satisfaction is sufficient evidence that calcite alone is not responsible for rapid weathering. One specimen of altered rock which the microscope showed to consist mainly of calcite resisted weathering tests better than altered rock that contained very little calcite. But finely crushed grains of calcite mingled with the other two minerals are subjected to an unusually severe test and have decomposed, whereas a similar fine aggregate of quartz or of unaltered feldspar would not have been appreciably affected.

The kaolin when exposed to the weather tends to absorb water which causes swelling and cracking and finally complete slaking. Specimens of thoroughly altered rock, however, when immersed in water did not slake, and alternate soaking for 24 hours followed by drying in the sun for 24 hours and continued for two months failed to produce any disintegration other than a very slight crumbling along the surfaces. The same specimens after being exposed to the summer sun but not to moisture for two months disintegrated almost completely. The primary cause of disintegration was the decomposition of the laumontite through loss of water. After this decomposition has started disintegration of the rock, the slaking properties of kaolin, the fine particles of which have become more exposed to the atmosphere, may aid in making disintegration complete.

Laumontite is a hydrous silicate of calcium and aluminum. Its chemical formula according to Dana's *Textbook System of Mineralogy* (page 457) is $CaAl_2\,Si_4O_{12} + 4\,H_2O$. Its tendency to lose its chemically combined water, however, is very marked and chemical analyses as well as records of its optical properties vary accordingly.

Microscopic examination of sound and unsound concrete showed that the feldspar aggregate in the sound concrete is mostly free from conspicuous alteration. Some fragments contain prominent veins of epidote and white mica. A very few are heavily sprinkled with very fine grained aggregate of the same minerals and perhaps with a very little of laumontite and kaolin, too small to be recognized. Some grains contain considerable calcite. The presence of several fine scales of white mica in the cement matrix suggests insufficient washing of the aggregate before use. Failure to wash ground unaltered feldspar may not be serious, but failure to wash the thoroughly altered rock would leave an abundance of the soft laumontite and kaolin dust to mingle with the cement matrix and create a tendency to rapid disintegration.

In one thin section of unsound concrete nearly all the feldspar grains are thoroughly altered to a fine aggregate of zeolite, kaolin calcite, and white mica. This concrete was so fragile that the thin section for microscopic study was much broken during preparation. The breaks were all in the cement matrix, which is darker than that in the sound concrete, due perhaps to the presence of considerable dust, which may have decreased the strength of the cement. In another thin section of unsound concrete the feldspar was less extremely though considerably altered, and several fragments of aggregate had been torn out of the matrix during grinding, suggesting that the strength of the matrix was satisfactory but that some of the grains were too much decomposed to resist grinding.

These microscopic differences together with the presence of relatively unaltered cores of rock in the quarry, account for the fact that the facings of some concrete blocks have disintegrated whereas others close by have remained nearly or quite intact. Unless care had been taken to mix thoroughly the finely ground aggregate only such irregular results could be expected.

CONCLUSION

This occurrence, so far as I know, is unique in the history of concrete. The fact that this altered-feldspar weathers so rapidly should not be regarded as an indication that feldspar, whether the potash-soda varieties (orthoclase and microbline) or the soda and lime-soda varieties (labite, obgoclase, andesine, labradorite, bytownite and anorthite) is undesirable as concrete aggregate. Stone consisting largely of one or more of these feldspars have resisted weathering for many years in buildings and other structures, and their feldspar constituents show little or no evidence of disintegration. Where slight alteration is evident the feldspar contained considerable finely divided calcite white mica, and kaolin—all of which are subject to slow chemical or mechanical weathering; but these minerals were developed by alteration long before the stone was quarried, and the effects of weathering simply indicate that the stone was poorly selected. Fresh or only slightly altered feldspar is not subject to rapid weathering.[2]

The real lesson taught by this experience is the necessity of making sure that any unusual or hitherto untried material is suitable for aggregate before putting it to such use. Any tests made should be of the material itself before tests of concrete containing it are begun. It would be ridiculous to assert that all materials for aggregates should be thoroughly studied and tested before being used, but where any doubt arises the time and money lost in having the material properly examined at first may save a vastly greater amount of time, money and trouble later.

SUMMARY

The most important results of this investigation may be summarized as follows:

The failure of the artificial stone in Los Angeles was due to the use of unsuitable aggregate, an altered lime-soda feldspar. Concrete made of this aggregate and exposed in Washington, D. C., has shown the same type of failure within a comparatively short period of time.

Tests specimens made up and tested in the manner usually prescribed for tests of aggregates did not indicate the unstable nature of the altered-feldspar aggregate. Long before the strength of the specimens was appreciably affected, disintegration was apparent from visual inspection. Attention is called particularly to the fact that strength tests alone are not sufficient to indicate the durability or acceptability of an aggregate.

It has been shown that the altered-feldspar (plagioclase) contained a large quantity of the zeolite, laumontite, which was primarily responsible for the disintegration; also kaoline, which tended to hasten the process of disintegration after it had started; also calcite, which, though relatively stable, tends to decompose rapidly when finely divided and in contact with water. Other alteration products were present but had nothing to do with the rapid disintegration. Residual cores of partially unaltered feldspar among the altered material have resisted weathering, and add to the evidence in general that lime-soda feldspar (plagioclase), if free from serious alteration when quarried, is not subject to appreciable weathering under ordinary conditions of use. The same statement may be applied to the potash-soda (orthoclase or microcline).

There is nothing in this case, therefore, to give rise to question regarding the permanency of feldspar aggregate as such. Feldspar aggregate free from serious alteration when quarried will, under any conditions, undoubtedly outlast any cement matrix which binds it together in the form of concrete.

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[2] An apparent exception is the "blistering" or scaling of granite; but this is primarily due not to the stone but to too severe hammering during the dressing of the stone. Granites with unusually large scales of mica or with an abundance of mica are more likely to suffer from this abuse, and pronounced alteration of their feldspars would render them still more so.

Some Defects In Concrete Buildings

Causes and How to Minimize by Proper Design[1]

By H. D. Loring
Ferro Concrete Construction Co., Cincinnati, Ohio

Many errors in the design of concrete buildings are not those that lead to collapse or even to cracks. The loss of labor and material due to wasteful designing or poor judgment in the selection of type of construction, loads, stresses, are real though unseen losses not less than such defects as are pointed out here.

Structural defects in reinforced concrete usually show as cracks; occasionally as disintegration without definite cracks, and less commonly as spalling or buckling. Such defects may be the result of accidents that cannot reasonably be foreseen but many of them can be prevented by proper design and precautions in construction. We are concerned here more particularly with those that can be corrected in the drafting room, and while most of those pointed out in this paper are not particularly unknown or obscure, it may be profitable to bring them again to the attention of designers.

Many structures are injured or rendered unsightly by cracks due to the applied loads for which they are supposedly designed. Pure blunders, we are of course not concerned with, but sometimes there are factors easily overlooked. Walls to retain earth or water are frequently designed as vertical cantilevers, and such walls seldom give trouble, when they are straight. When, however, two such walls are built at right angles to each other as a continuous structure, a wide crack is very apt to appear near the corner, because each wall bends, under the earth or water pressure, enough to cause rupture, even when considerable amounts of steel are bent around the corners. The rigidity of continuous floor construction is so well fixed in the minds of most building designers that they may not at first thought consider how comparatively limber a cantilever is, but recalling that a cantilever of uniform cross section under uniform load deflects 48 times as much as a similar fixed beam with the same span and load, will give one a measure of the deflection that may be expected in cantilever walls. The simplest and often the best preventive of such cracks is to design the walls as separate structures with a joint near the corners. Where liquids are to be retained, this is not practicable and the two walls may be connected by a curved or broken section of considerable radius with liberal horizontal reinforcements extending into each wall far enough to take care of stresses caused by restraint. For low walls a generous fillet in the corner with liberal horizontal reinforcement, may be sufficient.

On walls subject to fluid pressure, the overturning moment varies as the cube of the height, and is 2.37 times as much on an 8-ft. wall as on a 6-ft. one. Although earth-retaining walls are usually designed for fluid pressure, skepticism of such alarming precision is probably justified in view of the uncertainty as to just how much pressure earth does exert on a wall. However, several years ago when we were advised that a small retaining wall which had been built five or six years, was buckling out of line, we found that the fill behind it had increased from about 6 ft. to about 8 ft. and was being supported by wooden flash boards held by posts behind the walls. Soaking rains had contributed to the overload which had been sufficient to throw the wall considerably out of line. In choosing factors of safety the possibility of overload from excessive surcharges may well be borne in mind.

Effect of Cinder Roof Fills

A frequent source of trouble in concrete buildings having the roof insulated with a fill of cinders is the buckling of the cement topping placed over this fill to receive the roofing. The topping usually is a thin slab of rather lean mortar and unable to withstand the compressive stresses due to expansion at summer temperature, which will frequently raise large blisters. The resulting ridge cracks are very destructive to roof coverings and are a frequent source of troublesome leaks. Expansion joints are easily made in the topping with some of the prepared strips of bituminous material sold for the purpose or by leaving wood strips which are removed and the space filled with mastc. Such joints should provide for expansion in all directions at the rate of at least ½ in. for every 50 ft.

Cinder fills often become saturated from rains before topping is laid and the water slowly finds the only way out—through the ceiling, resulting in dampness for many weeks or even months. The cost of fill and topping with the cost of carrying their weight to the foundations may amount to 15c or 20c per sq. ft. and at best they do not form as good a foundation for roofing as a solid slab. This leads to the inquiry as to whether they may not be eliminated altogether in many cases. Inasmuch as composition roofing contractors will usually guarantee a dead level roof as readily as a sloping one, filling is not a necessity for forming slopes when it is not desired to pitch the structural slab for this purpose. The best reason for the use of cinder fill is as an insulator to prevent undue condensation on a cold ceiling in winter and excessive heat in the top story in summer. While cinder fills accomplish this result successfully and are desirable in buildings, with thin roof slabs in beam and slab construction, the greater thickness of structural concrete in flat slab construction is in many cases sufficient insulation in itself. We have examined several heated buildings constructed within the last year or two, where the roofing was applied directly to level structural slabs, and found them giving satisfaction. In one case, a portion of the building is used for office purposes with a plastered ceiling applied directly to the concrete and no condensation was noted or other trouble experienced by the occupants. The saving in the cost of roof fill is a considerable item in buildings where low first cost is imperative. In colder climates there is, of course, more necessity for the fill as a heat saver.

Expansion Joints

While expansion joints in fill toppings are absolutely necessary to prevent trouble in even buildings of moderate size, expansion joints in the building itself are another matter. The question of expansion joints in concrete buildings has been a much discussed one and probably the present tendency is to use them in fewer buildings. We believe they are seldom needed in buildings up to 300 ft. in length. Where they are used, careful designing is necessary to prevent their giving trouble, especially from leaking floors, in buildings where wet operations are carried on.

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[1] Abstracted from a paper read at the Convention of the American Concrete Institute, Cincinnati, O., January, 1923.

Perhaps the best form of expansion joint is one in which the adjoining parts are independent cantilevers. Such a joint used in the Anheiser-Busch building at St. Louis, was described in the technical press a few years ago. In another building, 560 ft. long, it was considered advisable to use an expansion joint which was secured by resting the ends of the beams carrying one side on brackets formed on the girders and columns of the other, to form a sliding joint. In this case, however, the frictional resistance developed by the dead load of the construction was sufficient to spall or pull off some of the brackets, rather than to permit sliding. In designing such brackets, either for expansion joints or to carry future extensions, care should be taken that sliding on the joint will take place before any destructive force may be transmitted to the brackets.

In beams, cracks of the well known shear variety may be caused by forces other than loading, for example, a slight settlement of supports, or of the form work before the concrete has fully set. These cracks are likely to occur as in shear failures, since the accumulated stresses are greatest at these points. Cracks of this kind can usually be avoided by placing stirrups throughout the beam, not further apart than three-quarters the effective depth, and repairs can be made by cutting out a section of the beam and floor, placing sufficient stirrups and re-concreting.

Exposed Structural Members

In many buildings having structural members exposed on the exterior, time and the elements have worked considerable damage, spalling and flaking of concrete and exposing steel to corrosion. Frequently the spalling is occasioned by the swelling of steel which has corroded when reached by moisture, due to insufficient covering; perhaps occasionally aided by electrolytic action. The great preventive of such unfortunate results is sufficient concrete protection for the steel. No such members should be designed with less than 2 in. minimum cover and 3 in. or 4 in. would often be desirable. Where bars are accidentally exposed during construction, the trouble should be remedied at the time. The dense surface finishes produced by rubbing in cement grout are a protection to the building as well as an addition to its appearance, while the bush-hammered effects and other finishes which expose aggregate should be used only when ample cover is given to the steel. Repairs to buildings so damaged are difficult and costly, but should not be neglected. The steel should have all loose scale wire-brushed or otherwise removed before pointing is done and every precaution taken to secure a bond for the pointing mortar. Metal lath may sometimes be used to advantage by tying to the reinforcing with galvanized wire. Painting the steel with a bituminous coating before pointing with mortar may prevent further corrosion.

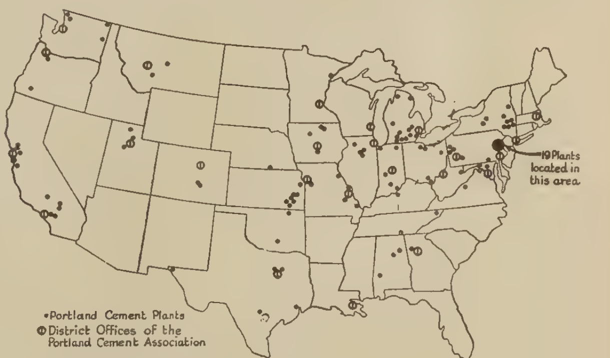
Some building codes encourage the placing of steel too near the surface by specifying that in vertically rodded columns only the concrete inside the ties may be counted to carry load. This appears to be based on an incorrect idea of the use of ties in vertically rodded columns; their function is, of course, only to stay the vertical bars and they cannot add anything to the strength of the concrete in the way that closely spaced spiral hooping does. Such test data as the writer has examined do not show any effect of changing the location of vertical steel in a column, as long as it is symmetrically disposed. In designing columns for bending moment, the position of steel must of course be taken into account.

There are many other points for the designer to bear in mind to facilitate the production of good concrete in the field, such as the proper location of construction joints, the reinforcement of re-entrant angles, the avoiding of sharp, thin sections and the design of sections and disposition of reinforcement that will permit concrete to flow into place readily. The skill of the organization doing the work has a bearing on permissible details. The speaker recalls a structure consisting mainly of 4-in. walls, 26 ft. high, which were poured in two lifts and showed hardly a flaw when the forms were removed. These walls had one layer of steel only, in the center, but in some work 8-in. walls would be the thinnest that could be used with confidence of tight work.

The designer who bears in mind that concrete is a brittle, porous material, manufactured in molds and usually used in continuous structures, will be likely to design structures which with reasonably good field work will not only have the requisite strength but are satisfactory in finish and as durable as we have a right to expect from the widely advertised "Concrete For Permanence".

Where Portland Cement Comes From

The accompanying map of the United States compiled by the Portland Cement Association is of interest showing where portland cement is manufactured. It is pointed out that the plants in this country have generally been built near the centers of population, but in numerous localities this has been impracticable because of the absence of suitable raw materials. There are 117 operating plants in the United States owned by 88 companies.


19 Plants located in this area
•Portland Cement Plants
⊙District Offices of the Portland Cement Association

Map Showing the Distribution of Cement Plants in the United States

As a comparatively young industry, cement has had to compete with other and long-established building materials and its popularity has been due among other advantages to its relative cheapness, according to the Cement Information Service.

In marketing all portland cement, it must as to quality meet the requirements of standard specifications which are the result of years of study of special committees of the United States Government, the American Society of Civil Engineers and the American Society for Testing Materials, and which are now in universal use.

The product of one manufacturer is by specification commercially identical with the like product of any other manufacturer, and portland cement of one brand does not command because of its quality a higher or lower price than any other brand.

Use of Calcium Chloride

As a Protection Against Freezing of Concrete

BY PAUL COTTRINGER AND HAROLD S. KENDALL
DOW CHEMICAL COMPANY, MIDLAND, MICHIGAN

Since the beginning of the use of portland cement for the purpose of binding together the various aggregates to form a solid stonelike mass, there has been present the problem of using this nearly universal building material during cold weather. This problem of course arises from the fact that the reaction between the cement and the water with which it is gauged is so slow that in weather that is at all below 32° F. the water will freeze before the concrete has attained more than a small fraction of its ultimate strength. What further aggravates this condition is that this reaction between water and the cement, very slow at ordinary temperatures, is slowed up many times when the temperature gets below freezing, so that a portland cement concrete, if exposed to cold weather conditions may attain only 5 to 10% of the strength that it would have reached had it been kept at ordinary temperatures for the same length of time.

Many methods of overcoming this inherent weakness of portland cement concrete have been attempted from time to time. These protective measures can, in general, be classified under two headings: first, the furnishing of artificial heat so that the concrete cannot freeze before the reaction with the water has been nearly completed, and, second, the addition of anti-freeze compounds to the mix.

The first means of protection can be passed over with the statement that this is absolutely the safest way, provided temperatures are well controlled and also, provided that the cost is not prohibitive. It might happen, however, that a careless night watchman would allow the fires to go out and ruin thousands of dollars worth of concrete or that the temperature might drop so suddenly that proper precautions could not be taken until too late. Even this means of protection is available only where the work is of such a form that a tent or shed can be used to enclose it, together with salamanders or other sources of heat. And, as indicated above, it is reliable only if a complete record of the temperature of the concrete is taken by recording thermometers.

The second means of protection; namely, the addition of soluble salts, is somewhat more complicated, but if the proper salt could be found there would be at hand an almost invaluable aid to the contractor who has a job that must be put in during the late fall, early winter, or early spring. In looking for such a compound, one would naturally look for the cheapest substance that would appreciably lower the freezing point of water. This, of course, would be sodium chloride or common salt. Considerable work has indeed been done with this material, and in some of the older handbooks there can be found tables purporting to give the temperatures at which various amounts of salt will keep portland cement concrete from freezing. It is now commonly recognized that sodium chloride has no accelerating effect on the setting of concrete and does have a decidedly deleterious effect on the ultimate strength that can be obtained at normal temperatures.[1] For this reason alone, the use of common salt as an anti-freeze in concrete cannot be recommended. Fortunately, there is at hand a material which has even a stronger anti-freezing property than salt, this property being combined with the power to greatly accelerate the setting of concrete mixtures. This material is calcium chloride, a natural salt which occurs in many natural brines and which is also obtained as a by-product of the manufacture of soda ash and caustic soda. It is comparatively cheap and universally obtainable. In general, calcium chloride can be obtained from the manufacturer either as a solid in light steel drums, or as flake in drums or burlap bags having a waterproof paper lining. Calcium chloride has been used for some time as protection to portland cement concrete and, as in the case of salt, there can be found tables which profess to give the amounts of calcium chloride that should be used to give protection at various temperatures. There has, however, been very little authentic work published on this problem that can be taken as a basis for these tables. It was because of this that the present work was undertaken.

CONDITIONS OF EXPERIMENTS

1. *Cement.*

The cement used for practically all tests was of the same brand and the product of one of the leading cement manufacturers. Some comparative tests were also made with several other brands of cement. The specifications of the American Society for Testing Materials were followed in sampling, testing, and storing the cements and in grading concrete aggregate. Cements Nos. 1 and 2 were found to be low in tensile strength and slow in setting time and were not used. Cement No. 3 was used in making cylinders Nos. 4 to 8, inclusive. Cements Nos. 4 and 5 were taken from the same carload as No. 3 and showed practically the same properties. No. 4 was used in cylinders Nos. 487 to 963 and No. 5 in cylinders Nos. 964 to 1439. No. 8 cement was taken from a different carload and was used in cylinders Nos. 1440 to 1660. Cements Nos. 6, 7, and 9 were different brands and were used in the following cylinders:

No. 6. 1661-1700,
No. 7. 1701-1740,
No. 9. 1741-1780.

The results of all cement tests will be found in Tables I to V, inclusive.

TABLE No. I
Chemical Analysis of Cements

Cement No.	3, 4, 5	6	7	8	9
MgO	2.32	2.15	2.89	2.31	3.22
SO_3	1.93	1.75	1.87	1.64	1.89
Loss on Ignition	0.78	2.29	2.00	2.24	2.33
Insoluble	0.53	0.60	0.65	0.30	0.79

TABLE No. II
Setting Time
(Hill Automatic Setting Time Machine)

	Initial	Final
Cement Nos. 3, 4	3 hr. 30 min.	6 hr. 45 min.
No. 5	4 hr.	7 hr. 15 min.
No. 6	4 hr. 15 min.	8 hr. 30 min.
No. 7	4 hr. 10 min.	8 hr. 10 min.
No. 8	4 hr. 45 min.	7 hr. 30 min.
No. 9	4 hr. 15 min.	7 hr. 30 min.

TABLE No. III
Soundness

(Over steam for five hours)

O. K. for all samples.

TABLE No. IV
Tensile Strength

1:3 standard sand mortar briquettes; 11.1% water or a water ratio of 0.668; all briquettes placed in moist cabinet for one day, then under water for balance of period. Each value average of six tests.

Cement No.	2 day	7 day	28 day
3-4	158	210	274
5	105	223	276
6	127	188	258
7	133	192	No test
8	133	171	242
9	No test		

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[1] *The Wisconsin Engineer*, October, 1913, Vol. 18, page 6. H. E. Pulver.

Table No. V

Fineness—Rotap Machine—45 Minutes

Cement No.	Percent passing 200 mesh sieve—.0029-in. opening
3-4	87.50
5	83.00
6	79.50
7	79.72
8	81.20
9	80.00

2. Aggregates.

The materials for the aggregate were all washed in a tumbler, dried, and sieved on standard Tyler sieves from 1½-in. to 100 mesh. The various components were then sacked and recombined as used to give a mixture with a fineness modulus of 5.71 and a sieve analysis which showed the following percentages retained on the sieves indicated.

0.75 inch	17 per cent
0.375 inch	51 per cent
4.0 mesh	68 per cent
8.0 mesh	75 per cent
14.0 mesh	79 per cent
28.0 mesh	83 per cent
48.0 mesh	98 per cent
100.0 mesh	100 per cent

The large pebbles included considerable crushed gravel and the small pebbles a mixture of smooth, fine grained quartz and granite.

3. Mix.

A mix consisting of 1 part cement to 5.2 parts of this aggregate was used for all test pieces. This corresponds to a 1:2:4 mix. Each batch was hand mixed according to the A. S. T. M. specifications in a quantity sufficient only for one cylinder, with a little surplus. Twelve kilograms of mixed aggregate were used with 1840 grams of cement and 1100 cc. of water, or water and calcium chloride solution. A slump of ½ in. to 1 in. is equivalent to a consistency of 1.00. A slump of from 5 in. to 6 in. or a consistency of 1.10, was obtained with 1100 cc. of water. The volume of water plus the volume of the calcium chloride solution was kept constant at 1100 cc. Slump tests were made with A. S. T. M. truncated cone, 12 in. high with an 8-in. diameter at the bottom and a 4-in. diameter at the top.

4. Molding.

Cylinders were molded principally in three-ply, paraffined, pasteboard cartons, approximately 6 in. inside diameter and 12 in. high. The molding, rodding and capping were done according to A. S. T. M. methods. The cylinders cured in refrigerating tanks were molded in cartons which were placed inside of tin cans to protect the cylinders from the brine. Some steel molds were used on the first cylinders made, but the type of mold had no effect on the results. From six to twelve duplicate cylinders were made for each point of each series. Cylinders were aged under different conditions for 2 days, 7 days, 14 days, 28 days, 3 months, 6 months, and one year.[2] Each series was made either in one day by three men or in two consecutive days by the same man.

5. Calcium Chloride.

The calcium chloride used was the "Dow Flake Calcium Chloride," manufactured by The Dow Chemical Co., Midland, Michigan. It was dissolved in water to make a solution of such strength that 100 cc. gave a 2% $CaCl_2.2H_2O$ content, based on 1840 grams of cement used per batch. The calcium chloride solution was mixed with the mixing water before it was added to the batch.

6. Storage Conditions.

Normal conditions were obtained by storing the cylinders under wet burlap at a temperature of 60 to 70° F. Outdoor freezing conditions were obtained by making the cylinders inside at a temperature of about 55° F., with aggregate, water, and cement at room temperature, and storing outside in weather conditions of February and March, 1922; also by making the cylinders outside with cold aggregate, water, and cement, and storing outside. These conditions, although being actual working conditions, were quite variable, and the resulting curves are somewhat irregular. Artificial and, therefore, more constant freezing was obtained by storing the cylinders in tin containers set in a refrigerating mixture of calcium chloride, water and ice. In most cases, good reliable checks were obtained.

7. Thawing.

At the beginning of the experiments, it was found that a frozen cylinder broke at a much higher strength than a thawed cylinder and that a very short period at temperatures of 80 to 85° F. was necessary to thaw the cylinders. Consequently, all frozen cylinders were placed in a warm air blast for from one to two hours, then held at normal temperatures until broken. The total time from the beginning of the thaw until the last cylinder was broken would approximate 7 to 8 hours. This extra thawing under an air blast was, of course, unnecessary during the warm summer months.

8. Testing.

Compression tests on most of the cylinders were made on a 100,000-lb. Riehle' motor-driven machine. The base block was a ball and socket, self-centering block, the top block being rigid. Some of the six-month cylinders were tested on a 200,000-lb. Olsen Universal Testing Machine. The pasteboard cartons were removed from all low strength cylinders only before testing and thin cardboard cushions were used on any cylinders having slightly rough or uneven ends.

Discussion

Practically all of the data has been tabulated in Table VI and graphically represented by the curves below, but some discussion of the curves will probably make them more clearly understood. The first set of curves on Plate I are the normal condition curves, showing strengths at 2 days, 7 days and 28 days. The three curves shown were obtained by averaging all the values for Series Nos. 11, 17 and 26 for 2-day values; 8, 15 and 25 for 7-day values; and 12 and 29 for 28-day values. The 2-day curve shows the greatest strength at 10% calcium chloride and the lowest at zero per cent, while the 7-day curve shows an entirely different result, that is, the lowest strength is at 10% and the greatest strength at 2%. The 28-day curve also shows the greatest strength at 2% calcium chloride with a 10% strength very little greater than the 0% calcium chloride.

Plate I

The second set of curves on Plate I shows the results of tests in cylinders made inside and stored outside in winter weather. It is also the average of several series and shows the results obtained in actual cold weather conditions. The 2-day curve is the average of Series 5, 10 and 19; the 7-day curve of Series 6, 13 and 18; and the 28-day curve of Series 3, 14 and 28. The 3-month series curve is a single series, No. 4. Again, in the 2-day series, we find the greatest strength at 10% and the lowest point at 0 %. although we find another peculiarity, that is, a low point at 6%. This point, however, is no lower than the point at 0%. We notice this low point in the 7-day curve although the 0% point is much lower than the

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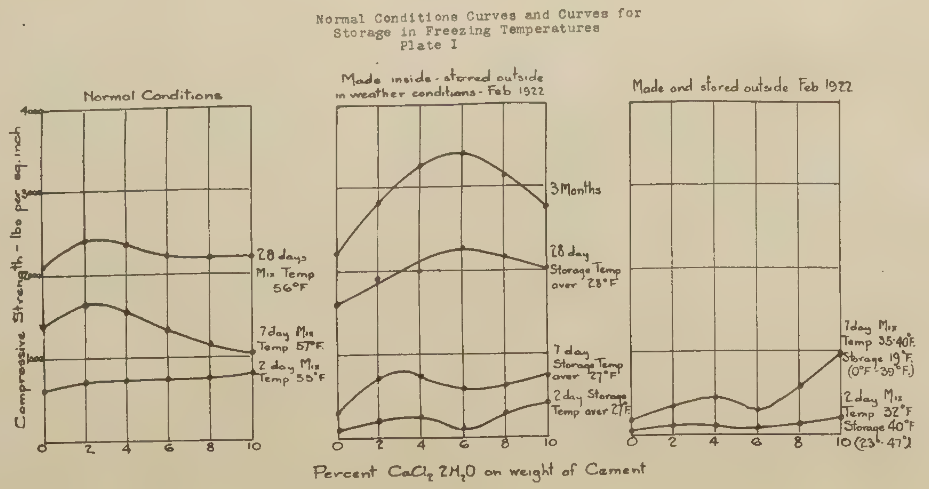
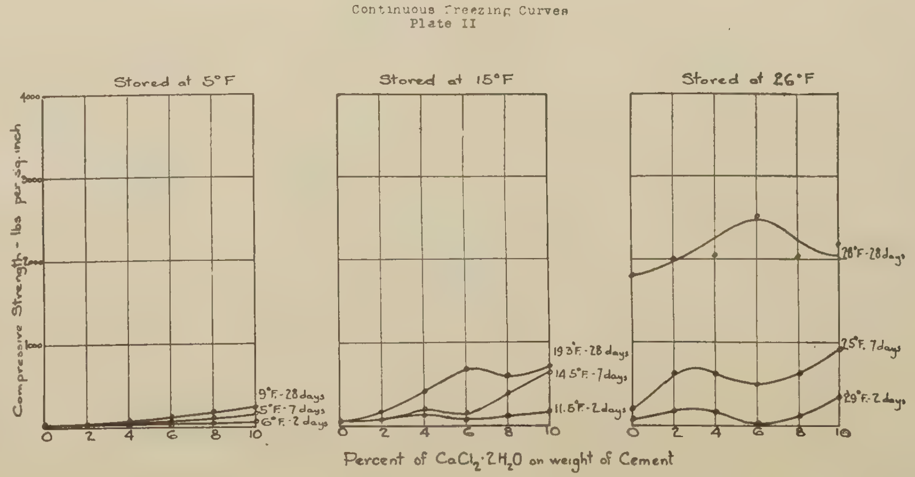
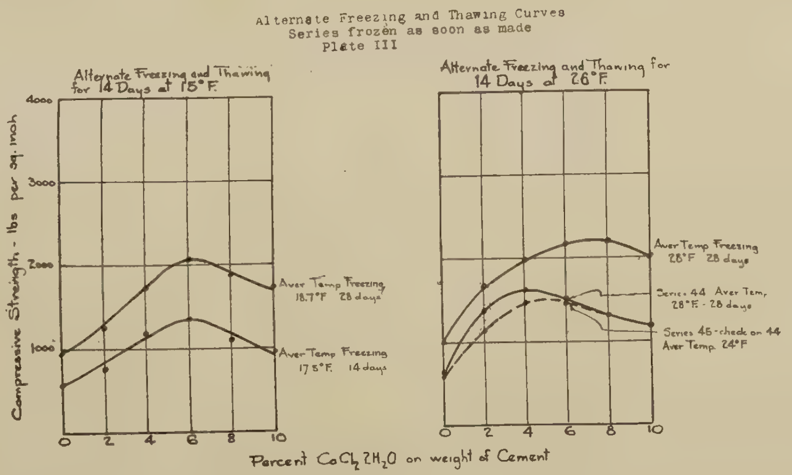
[2] One-year test not ready.







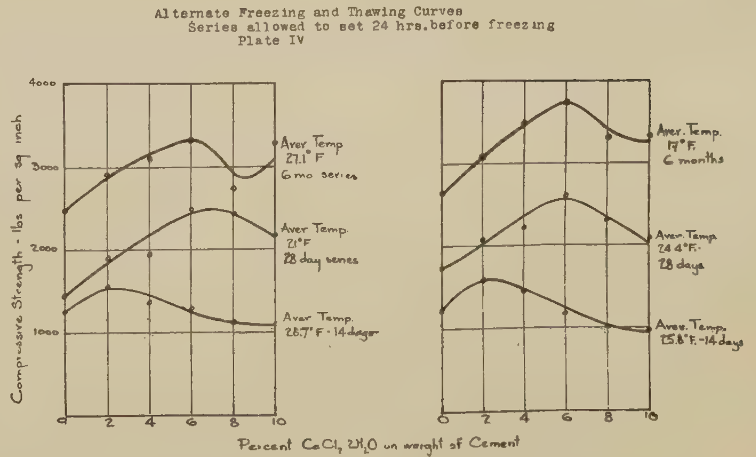


PLATE I. NORMAL CONDITIONS CURVES AND CURVES FOR STORAGE IN FREEZING TEMPERATURES

PLATE III. ALTERNATE FREEZING AND THAWING CURVES. SERIES FROZEN AS SOON AS MADE

PLATE II. CONTINUOUS FREEZING CURVES

PLATE IV. ALTERNATE FREEZING AND THAWING CURVES. SERIES ALLOWED TO SET 24 HRS. BEFORE FREEZING

6% point. The 2 and 4% points are practically as high as the 10% point. Going, then, to the 28-day curve, we find the maximum point at 6% just where we found the low point in the shorter time tests. This high point again appears on the 3-month test and on the latter curve the high point is 150% of the 0% strength, which is indeed a remarkable increase.

The third set of curves was taken from single series and represents a condition of cold aggregate, mixing materials, and storage. The 2-day curve is Series No. 7, and the 7-day curve is Series No. 9. The 2-day curve shows low points at 0% and 6% and the high point at 10%. The 7-day series also shows low points at 0% and 6% and an extremely high point at 10%. A word of explanation of the storage conditions of the 2-day series may make the results seem more consistent. In this series, the average storage temperature is given as 40° F. This apparently high storage temperature is due to the fact that, although during 28 of the 48 hours of storage the temperature was below 32° F., on the second day the temperature rose to 47° F. It might also be stated that when this series was made the weather and materials were so cold that, in the case of the 0% calcium chloride test pieces, ice particles were formed during mixing.

Plate II shows the effect of continuous freezing. As has been stated above, this condition was obtained by artificial means and could therefore be more carefully regulated. Refrigerating temperatures were read every hour and the average for the day calculated therefrom. The first set of curves shows the effect of continuous freezing at about 5° F. The 2-day curve is Series No. 22, the 7-day curve Series No. 21, the 28-day curve Series No. 20. At 0% calcium chloride, the strengths were practically nil. In fact, several of the cylinders actually fell apart when the pasteboard cartons were removed. However, there was a gradual increase in strength up to 10% calcium chloride. On the basis of the strength at 0%, of course the strength at 10% shows a very high percentage increase. But this strength is much below the requirements for good concrete. This condition is the worst we have tried to show and from the results we find that at this temperature, unless some means of externally applying heat is used, calcium chloride alone will not insure the setting of the concrete. Much the same results were obtained at 15° F., shown in the second set of curves on Plate II. These curves are a little more irregular and, as we might expect, are higher than those at 5° F. The 2-day curve is Series No. 23, the 7-day curve is Series No. 27, and the 28-day curve is Series No. 40. The highest strengths are at 10%, the lowest at 0%. However, as has been noticed, there is a low point at 6% on the 2- and 7-day curves and a high point at 6% on the 28-day curve. This checks the second and third sets of curves on Plate I. We hesitate to recommend the use of calcium chloride alone as an anti-freezing preparation at conditions of temperature which remain continuously as low as 15° F. It can be readily seen that, although the strength at 28 days is not what a good concrete should have—even with 6% $CaCl_2.2H_2O$—it is nevertheless almost ten times as strong as the concrete without calcium chloride.

PLATE II

In the third set on Plate II, we find much more satisfactory results. This set of curves shows conditions of continuous freezing at approximately 26° F. The 2-day curve is Series No. 19, the 7-day curve is Series No. 18, and the 28-day curve is Series No. 28. Here again, we find the high point at 10% calcium chloride and the low point at 0% for the 2- and 7-day curves, with another low point at 6%, while on the 28-day curve we find our highest point at 6%.

On Plates III and IV we have represented entirely different conditions of curing; namely, alternate freezing and thawing of the test pieces. By alternate freezing and thawing we mean that the pieces were put in refrigerating tanks for 24 hours at freezing temperature and then taken out and allowed to stand for the next 24 hours in temperatures of from 70° to 80° F. At the end of this time, the freezing and thawing were again repeated. This was continued for 14 days at the end of which time some of the cylinders were broken, some were allowed to stand for 14 more days, and some for a total time of six months.

PLATE III

The first series of curves on Plate III shows alternating freezing and thawing conditions when the temperature during the days when the cylinders were frozen was held at about 15° F. The 14-day curve is Series No. 41, the 28-day curve is Series No. 42. In both these curves, we find the highest point at 6% calcium chloride, while 3% calcium chloride will give as great strength in 14 days as 0% does in 28 days. The increase in strength with 6% calcium chloride over 0% is remarkably high and the second set of curves on Plate III, representing conditions at 26° F., shows very much the same results. The 14-day curve represented by the solid line is Series No. 44; that represented by the dotted line is Series No. 45. The solid curve shows the highest point at 4% calcium chloride, which is at variance with the results heretofore obtained. However, the dotted curve shows 6% to be just a few pounds higher than 4%. Series No. 45 represented by the dotted curve was run with extreme care in an attempt to check series No. 44. How nearly this was accomplished can be seen by comparing the curves. The dotted curve is a little lower, owing possibly to the fact that the average temperature was maintained at a slightly lower point. However, the curves check very satisfactorily. The 28-day curve is Series No. 43, and here we find the highest point at about 7% calcium chloride, although again this point is but little higher than 6%. In view of the results of our other tests, 6% calcium chloride is a sufficiently high percentage to use.

PLATE IV

The curves on Plate IV might be taken as indicative of the results that would be obtained in massive construction wherein the concrete would have sufficient heat in itself to keep the temperature above the freezing point for some time. These test pieces were allowed to stand 24 hours before they were frozen the first time. The second series on this plate is a check on the first series. Here are also shown the results of our six-months' tests. Both six-month curves show high points at 6% $CaCl_2.2H_2O$, although in the first set the 10% point is practically as high as 6%. In the second set the 6% point is considerably higher than any other point.

Plates V and VI were made in connection with the freezing and thawing experiments to show conclusively that the cylinders were actually in a frozen condition when taken out of the refrigerating mixture. The results were obtained as follows:

Small glass tubes just large enough so that a thermometer would fit inside of them and closed at the bottom were imbedded in the middle of the top of several test pieces. These tubes extended nearly half way to the bottom of the cylinder. A little brine

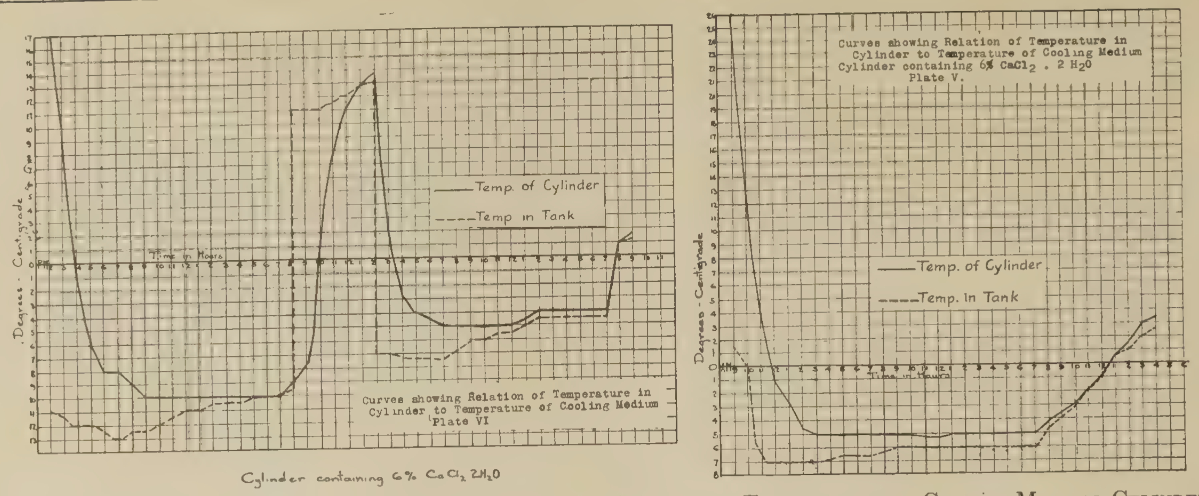


PLATE V. CURVES SHOWING RELATION OF TEMPERATURE IN CYLINDER TO TEMPERATURE OF COOLING MEDIUM CYLINDER CONTAINING 6% $CaCl_2.2H_2O$

PLATE VI. CURVES SHOWING RELATION OF TEMPERATURE IN CYLINDER TO TEMPERATURE OF COOLING MEDIUM

was put in each one to exclude air currents. A thermometer was placed in the tube and the test piece put in the refrigerator. The temperatures of the cylinder and brine were taken every hour and the resulting temperatures plotted.

PLATE V

At the beginning of the tests the temperature of the cylinder was comparatively high, but rapidly dropped until near the temperature of the brine. The reasons it did not drop as low as the brine are probably due to the fact that the top of the cylinder was not properly insulated, and also probably because of the generation of some little heat within the cylinder, caused by the setting of the cement.

PLATE VI

In Plate VI the sudden rise in temperature was brought about by removing the cylinder from the cold brine and putting it in the tank at approximately room temperature.

Having obtained the foregoing results, it was thought advisable to try the effect of calcium chloride on several other brands of cement. These cements we have labeled Nos. 6, 7 and 9. The tests tried were alternate freezing and thawing for 14 days at approximately 20° F. cold condition. The results obtained are tabulated under Series 46, 47 and 48, and the curves are shown on Plate VII. Cement No. 9 shows a high point at 6% which checks our previous results.

PLATE VII

Cement No. 6 shows nearly a straight line curve from 4 to 10% with 10% a very little higher than 4%, but cement No. 7 shows 8 and 10% as the highest points, although 4 and 6% are very much higher than 0%. In view of the fact that these results are obtained from only one series for each cement used, we do not feel that they are as conclusive as the results heretofore shown although they do in a general way check these results.

In any discussion of the use of calcium chloride in portland cement concrete there always arises the question as to whether or not there will be any increase in the corrosion of the reinforcing steel. It might be said in this regard that calcium chloride, particularly when there is present even a small amount of substances capable of giving an alkaline reaction, as there is in cement, does not have any corrosive action on steel. This has been repeatedly proven in our laboratories in connection with other work, such as corrosion of iron tanks in refrigerating installations.

In order to check this conclusion, several concrete specimens were made, their dimensions being 24 in. long by 6 in. wide by 6 in. deep. These were made of calcium chloride from 0 to 10%. In each of these specimens, at the time of being formed, was placed a piece of ¾-in. steel rod about 18 in. long, in such a position that the ends of the rods were both covered with about a 3-in. layer of concrete. Some of these specimens were given a coating with a thick slurry of milk of lime while others were imbedded in the concrete just as they were. All of these specimens were exposed for a period of a year, at the end of which time they were broken open and an examination made of the reinforcing steel. As near as could be told by a very careful examination there had been no corrosion of either the specimens in the concrete which contained calcium chloride nor in any of the others.

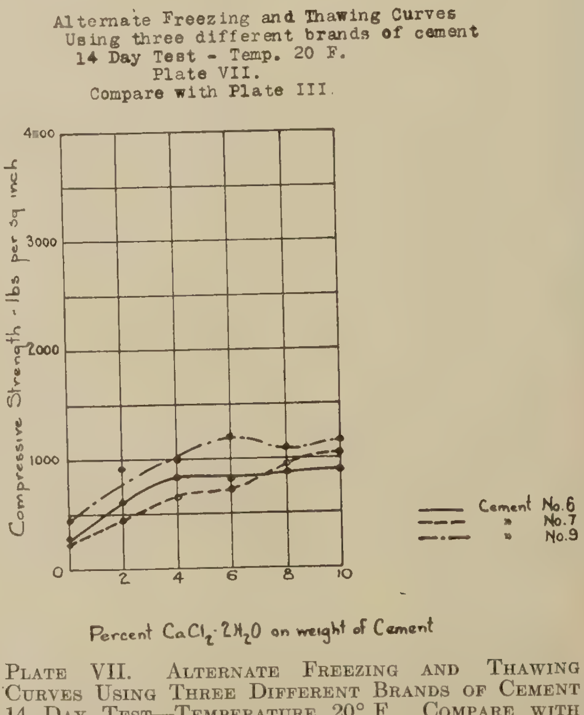


PLATE VII. ALTERNATE FREEZING AND THAWING CURVES USING THREE DIFFERENT BRANDS OF CEMENT 14 DAY TEST—TEMPERATURE 20° F. COMPARE WITH PLATE III

SUMMARY OF TESTS

Date	Series	Cylinder No.	Age at Test	Ave. Mix Temp. F.	Storage Temp. F	Cpmpressive 0%	Strength 2%	in lbs. per sq. in. 4%	6%	8%	10%
1-30-22	1	4-39	2 days	60	21 - 44	314	335	544	885	959	936
1-31-22	2	40-75	1 year	60	outside						
2-2-22	3	76-111	28 days	53	0 - 47 26	1584	2045	2048	2127	1954	1847
2-3-22	4	112-147	3 months	54	outside	2196	2986	3270	3395	3145	2730
2-4-22	5	148-183	2 days	59	25 - 31 29	179	291	367	332	692	852
2-7-22	6	184-219	7 days	59	13 - 47 27	537	1085	917	746	833	833
2-8-22	7	220-255	2 days	32	23 - 47 40	44	127	123	58	122	313
2-10-22	8	256-291	7 days	55	60	1363	1400	1276	1176	1144	1075
2-11-22	9	292-327	7 days	35 - 40	0 - 32 19	183	353	442	323	564	983
2-11-22	10	328-342	2 days	50	17 - 32 23				54	95	182
2-13-22	11	343-378	2 days	45 - 60	60	443	611	659	673	863	897
2-15-22	12	379-414	28 days	52	60 - 70	2280	2750	2535	2060	2200	2150
2-16-22	13	415-450	7 days	47	10 - 39 27	269	539	591	481	444	441
2-17-22	14	451-486	28 days	48	26	1440	1820	1762	2155	2260	2070
2-22-22	15	487-522	7 days	60	60 - 70	1434	1968	2000	1673	1299	1025
2-22-22	16	523-528	7 days	65	60 - 70	341					
2-23-22	17	529-570	2 days	60	60 - 70	807	900	831	898	643	875
2-24-22	18	571-606	7 days	55	16 - 36 25	197	627	650	478	619	925
2-25-22	19	607-642	2 days	55	20 - 36 29	61	171	159	27	126	288
3-2-22	20	643-684	28 days	57	9	18	32	80	111	167	224
3-3-22	21	685-720	7 days	60	5	13	23	50	65	110	183
3-4-22	22	721-756	2 days	55	6¼	8	22	49	37	48	74
3-6-22	23	757-792	2 days	67	11½	32	82	135	80	146	180
3-8-22	24	793-828	28 days	60	14½	37	100	192	190	238	358
3-10-22	25	829-864	7 days	55	60 - 70	1402	1547	1419	1112	1070	1018
3-11-22	26	865-900	2 days	55	60 - 70	612	611	750	624	761	635
3-20&21	27	901-940	7 days	60	14½	17	41	216	133	437	666
3-22&23	28	941-980	28 days	55	28	1785	2000	2040	2560	2200	2490
2-27&28	29	981-1020	28 days	60	60 - 70	1895	2120	2170	2340	2170	2230
3-30&31	30	1021-1060	14 d. F.& T. -6 mo.	54	27.0	2450	2920	3020	3360	2770	3300
4-10&11	31	1061-1100	" " " " " "	64	19.4	2870	2930	2670	3240	2940	2880
4-12to14	32	1101-1140	" " " " " "	54 - 64	17.0	2670	3080				3400
4-19&20	33	1141-1180	" " " " 28 da.	55	21.0	1434	1872	1916	2505	2390	2160
4-26&27	34	1181-1220	" " " " " "	53	24.4	1750	2080	2160	2613	2280	2090
5-1&2	35	1221-1260	" " " " " "	65	31.7	1895	1975	1963	2285	1960	1880
5-15&16	36	1261-1300	" " " "	67	25.8	1262	1595	1428	1170	1075	1105
5-22&23	37	1301-1340	" " " "	67	28.7	1240	1549	1330	1365	1123	1085
5-24&25	38	1341-1380	" " " "	68	29.3	1450	1620	1720	1775	1650	1410
6- 9&10	39	1381-1420	7 days	75	16.6	40	147	183	569	684	642
6-12&13	40	1421-1460	28 days	66 - 68	19.3	52	179	415	686	580	720
6-21&22	41	1461-1500	14 d. F.& T.	68 - 72	17.5	555	708	1148	1355	1050	970
6-23&24	42	1501-1540	" " " " 28 da.	70 - 77	18.7	970	1250	1750	2075	1890	1750
7-17&18	43	1541-1580	" " " " " "	70 - 74	26.0	976	1675	1955	2145	2235	2000
7-19&20	44	1581-1620	" " " "	68 - 70	27.2	598	1385	1640	1490	1290	1225
8-28to30	45	1621-1660	" " " "	61 - 68	24.0	559	1102	1445	1448	1279	1194
10- 10	46	1661-1700	" " " "	60 - 64	20.0	293	640	843	830	866	990
10-12&13	47	1701-1740	" " " "	57 - 62	20.0	250	480	695	735	970	1070
10-21to23	48	1741-1780	" " " "	60	20.0	475	945	1000	1220	1080	1195

CONCLUSIONS

Calcium chloride when used in proper amounts is very beneficial to concrete that will be exposed to cold weather conditions. There is a gradual increase in strength with the amounts of $CaCl_2.2H_2O$ used at the various temperatures up to the maximum (6% $CaCl_2$). This shows the fallacy of a table which would pretend to give definite temperatures at which concrete would be protected from freezing. It can be seen that at any temperature below 32° F. 2% $CaCl_2.2H_2O$ is better than none, 4% is better than 2%, etc., up to the maximum at 6%. Two % $CaCl_2.2H_2O$ is indicated for normal conditions of curing while 6% should be used when cold weather is expected.

Calcium chloride will not keep the concrete from freezing at any temperature lower than the freezing point of the calcium chloride solution with which the concrete is gauged. (With 6% $CaCl_2.2H_2O$ and with a consistency of 1.10 the water solution will freeze at about 25° F.)

Calcium chloride has a very beneficial effect, even if temperatures are so low that the concrete will freeze, the strength with 6% $CaCl_2.2H_2O$ being in some cases ten times that obtained when no calcium chloride is used.

Six per cent $CaCl_2.2H_2O$ does not give the maximum strength at early ages but does give maximum strength at ages over 7 days. No explanation of this phenomenon can be offered at this time.

If temperatures of 20° F. or lower are expected continuously, protection by artificial heat must also be provided, if reasonable strength is to be obtained in a short time.

Amounts of calcium chloride in excess of 6%, while beneficial at very low temperatures in early ages (2-7 days), do not give as good results as does 6% at later ages.

Calcium chloride will protect concrete at lower temperatures under alternate low temperature and high temperature conditions than under conditions of continuous low temperature.

While with some brands of cement, 6% did not give the maximum strength obtainable by using calcium chloride, it gave only slightly lower strengths than this maximum, and in no case did it give a lower strength than that obtainable with 2% or 4%.

Based on the extremely preliminary work outlined above, it can be said that no additional corrosion of reinforcing steel will be found when calcium chloride is used, particularly in the absence of stray electric currents.

Contractor's Plant[1]

Report of the American Concrete Institute Committee

The broad question of when chutes may and may not be used with economy is one to which contractors are giving increasingly careful thought, particularly in view of the increased labor efficiency now obtainable and the lowered wage scale. Conditions in the labor market have changed materially in the last two years, since the various charts were printed in the report of this committee. The present situation as regards supply and efficiency of labor is probably a much more normal condition than that which existed then and the committee has replotted the charts already published.

The charts have been redrawn on a basis of plant equipment costs for the Fall of 1922 for the same layouts as in 1921. Labor rates have been reduced to $4.50 for 8 hours, as wage scales throughout the country have been generally established at new and lower levels. A few territories are still maintaining peak wages, but they are exceptions.

The new charts are intended to be self-explanatory and will not require reference to last year's report.

SECTION 1. ANALYSIS OF CHUTING & WHEELING PLANT

The principal problem facing a contractor in making a decision as to what kind of plant to use on a certain concrete structure is a proper conclusion as to the relative merits of placing concrete by means of wheeling or chuting. One method or the other may be obviously more suitable for a certain job and here the decision is easy to make without any chance of error, but for each job like this, there will be many places of work where the correct choice may only be made after a careful study has been given to all of the conditions governing the work to be done, as affecting the relative economy of one type of plant or the other.

Wheeling has been used in the past for almost every type of building operation. It has been favored because of the low cost of plant installation and negligible upkeep charges. Its effectiveness is limited chiefly by the distance which it may be necessary to wheel from the mixing plant. It is always theoretically possible to use enough wheelers to take away the concrete as fast as it can be mixed (barring labor shortage). The number of men required to maintain a given speed of fill however, will increase with each addition to the distance from the hoist tower to the point of deposit of the concrete in the forms. Starting, therefore, with the lowest cost for placing concrete in front of the mixer, the labor cost per cu. yd. will rise with each addition to the haul. With a chuting plant conditions are otherwise.

Chuting plants are of two general types. The self-contained type, usually of about 100-ft. radius, is hung from the hoist tower direct by means of a suspended boom and counter-weight chute. In the older or "line chute" method the chutes are suspended from a cable run between towers or between towers and anchorages.

The plant cost and installation, and the upkeep charges, as well, are usually higher for chuting than for wheeling plants. When chutes are used the labor required to take care of any given mixer capacity is the same at long distances as it is at the mixer, the increased distance to be covered being taken care of by added chutes. The plant investment and installation cost, however, will vary with the distance to be spanned, for since the slope of the chutes with reference to the horizontal cannot be reduced below a certain fixed angle it follows that for long reaches there must be added the cost of the extra length of chute plus a charge for the corresponding increase in the height of the tower.

There are, of course, many other factors affecting the choice between the two methods of placing in addition to the few that have already been mentioned. Principal amongst these may be mentioned the character of the building, the cost of freight and repairs, interest on investment and the kind of equipment which is available as well as the amount of experience which local labor has had in concrete construction. These items will be dealt with in more detail in the analysis of the two systems.

The one point to be considered is the character and type of building. It may be assumed that any typical building job can be wheeled, with the number of mixing plants depending upon the contractor's individual preference as to the distance he cares to wheel from the tower. As a rule this is limited to about 200 ft. parallel to the long axis of the building and 100 ft. to 150 ft. across the building, or over an equivalent area. Whether the labor cost thus obtained can be economically lowered by a heavier investment in plant is usually the crux of the problem.

Chutes do not lend themselves so readily to all types of building. A nearly square structure is obviously best adapted for the 100-ft. radius type. The building should preferably have a high yardage or a number of stories although "H" or irregular shaped buildings which may be enclosed in an approximate square can usually be handled as advantageously. Long narrow structures one or two stories high with low yardages are not adapted for this method of placing, for example. With the same plan of building, but with greater yardage and more floors, one 100-ft. radius plant may be used to pour part of the building and by chuting to a floor hopper cut approximately 130 ft. off the wheel required to reach the rest of the building. Two independent 100-ft. radius plants may be used, or one mixing plant, a line chute to a re-hoist tower, and 100-ft. radius plants mounted on both towers.

In other cases, two adjoining buildings may be reached by the one 100-ft. radius plant, or one building may be chuted in entirety and the chutes used only to deliver concrete to a floor hopper in the second building. For groups of isolated buildings, line chutes will sometimes solve the problem of material delivery to what would otherwise be inaccessible mixing plants by the installation of a central mixing plant and the distribution of the mixed concrete instead of the raw materials.

The first step is to find out whether the job is one to which chutes will lend themselves without forcing. If by a general inspection of the conditions such is found to be the case, it is then proper to outline a plant layout for each method of placing and make an analysis of the advantages and disadvantages of each.

The next step in the decision as to which type of plant is economical and suitable for a certain piece of work is to determine as accurately as possible the cost of each so that the one giving the lowest ultimate cost of mixing and placing concrete may be selected.

This ultimate cost may be separated for the purpose of analysis into the following items:

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[1] Abstracted from the report of the committee as presented at the convention of the American Concrete Institute, Cincinnati, O., January, 1923.

1. Rental of Plant Involved.
2. Installation—Labor and Material.
3. Maintenance of Plant—Labor and Material.
4. Operating Cost of Plant—Labor and Material.

Rental of Plant

Item No. 1 is arrived at in several different ways by different contractors. The simplest, though not the most economical to the job, is to purchase suitable plant at the beginning of the work and sell it upon the completion of the job; the difference between the purchase and the sale price then represents the charge to be made as rental of plant. This method of handling plant account is practiced by several of our largest and more progressive general contractors and eliminates the trouble of the plant yard and the accumulation and maintenance of quantities of partly worn out and more or less out of date machinery.

The usual way to handle this account is for a general contractor to maintain a suitable plant yard and charge each job a rental for the items of plant furnished to the work. This charge can be either a fixed amount agreed upon for the work in hand or a monthly rental for the various items of machinery furnished. The amount of rental depends upon the value of the machinery and the rapidity of its depreciation and varies generally from 5% to 15% per month of its initial value. Motors, engines, hoists, etc. with proper maintenance, will not depreciate in value more than 5% a month. Mixers, boilers, etc. will depreciate 10% per month and concrete parts, chutes and like items of plant will depreciate up to 15% per month. Other smaller items, such as belting, shovels, wheelbarrows, etc., which are apt to be used up or destroyed during the life of an average job, are not generally considered as plant but as supplies and are bought by the job and any salvage value which they may have upon the completion of the work is credited to the part of the job for which they were purchased.

The transportation of the plant including freight, trucking, loading and unloading, both to and from the job, is a proper part of the plant rental item.

Installation Cost

Item No. 2 includes all charges for labor and material entering into the setting up of the machinery at the beginning of the work. This includes the construction of storage bins, cement sheds, hoist towers, floor hoppers, run panels and such miscellaneous items as really form a part of the completed plant for mixing and depositing of concrete. This cost of installation also includes any additions to this plant or changes in the arrangement of the same which may be necessary during the operation of the job and also includes the cost of taking down the plant upon the completion of the work. The salvage of any lumber or timber or other items which enter into the construction of the plant but do not form a permanent part of the machinery, are to be credited to this item.

The cost of running water lines to mixer, bringing in electric power with setting of transformers, switches, etc. must also be included. If steam is obtained from nearby sources, cost of necessary connections and piping must be added.

Fuel to operate a steam plant or electric power charges are obviously operating costs.

Maintenance

Item No. 3 includes the cost of all labor and material used in maintaining the plant in good working order so that the machinery may leave the job in as good condition as it arrived except for the ordinary wear and tear. To this item is also charged the cost of replacing parts broken during the life of the job.

Operating Cost of the Plant

Item No. 4 is principally a labor charge, the only material entering into it being the cost of fuel, water, lubricating oils, waste, etc., and electric power in case electricity is used instead of steam. The labor in this item includes the actual operatives of the plant such as engineers, firemen, hoist runners, mechanics, etc. as well as the force of laborers employed in charging the mixer with the materials of concrete, and the larger force of laborers employed in moving run panels or chutes, as the case may be, as well as actually placing the concrete in the forms, whether it be by carryalls or chutes.

It is logical to expect that any increase in expenditures for items Nos. 1, 2 and 3 will cause a sufficient decrease in item No. 4 to make the summation of the four items a minimum, for the object of the plant used is to get the concrete in the forms for the least amount of money and all charges against this part of the work are included in the four items outlined.

Serious shortage in the labor market or necessity for extreme speed in placing concrete, may influence the choice of plant which would not normally be selected. The actual value of those two conditions can generally be determined with sufficient accuracy so that proper weight may be given to their influence in changing any layout of plant which would normally be decided upon.

In the comparative analysis of the two methods of placing concrete, the majority of items will be found common to both the wheeling and the chuting systems, although the charges for those items will often vary for each.

Principal among the items common to both will be:

Towers and guy lines
Mixers
Hoist Drums
Hoisting buckets
Electric motors or steam engines and boilers and electric wiring or steam piping
Concrete carts
Floor hoppers, gates, etc.
Run panels with horses, etc.

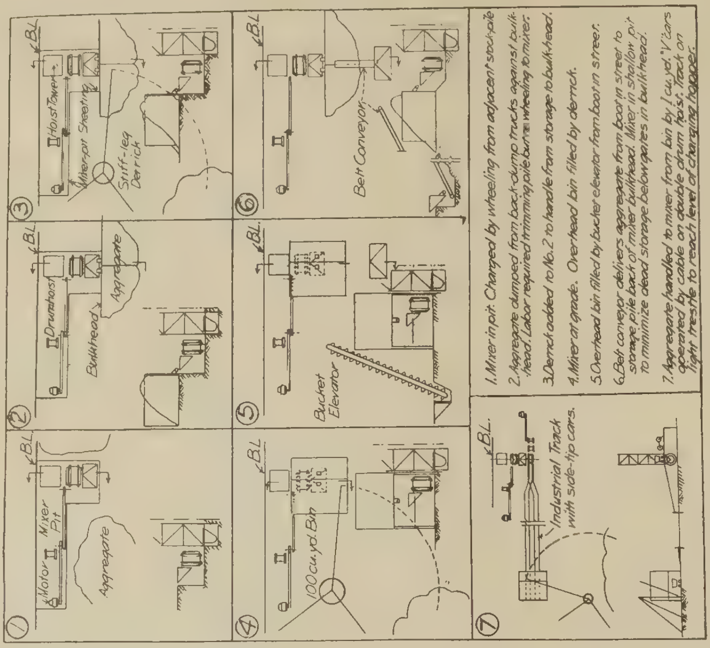
In the case of a wheeling job, large numbers of carryalls will be used with their necessary run panels and supporting horses. There will probably be a single drum type of hoist used and the hoist tower and floor hoppers will be built of wood. A number of carryalls and run panels sufficient to reach the most remote parts of the work must be provided for. The size of the wheeling gang must be determined for the whole job as that sufficient to take care of a little more than the average haul which will be half way from the tower to the most extreme part of the building. The charging and placing gang will remain about uniform throughout the job.

Where chuting plant is decided upon, it will either be of the counterweight boom type or the line chute type.

In this case the special equipment will be about as follows:

Steel Towers with base and head frame
Sliding frame with hopper
Boom and counterweight truss
Extension chutes
Special hoist bucket
Intermediate hoppers or additional sliding frame and hopper

There will be much heavier guy lines needed and many more of them as every other 20-ft. panel point of tower needs support. The hoist cable will be of greater length due to the increased height to which it is necessary to elevate the concrete. A double drum hoist will be necessary so that the second drum may be available for the movement of the sliding frame, without delaying operations. The motor and drum will have to be of considerably greater capacity due


① Motor, Mixer Pit, Aggregate, B.L.
② Drumhoist, Bulkhead, Aggregate, B.L.
③ Hoist Tower, Mixer pit, Sheeting, Stiff-leg Derrick, B.L.
④ 100 cu. yd. Bin, B.L.
⑤ Bucket Elevator, B.L.
⑥ Belt Conveyor, B.L.
⑦ Industrial Track with side-tip cars, B.L.

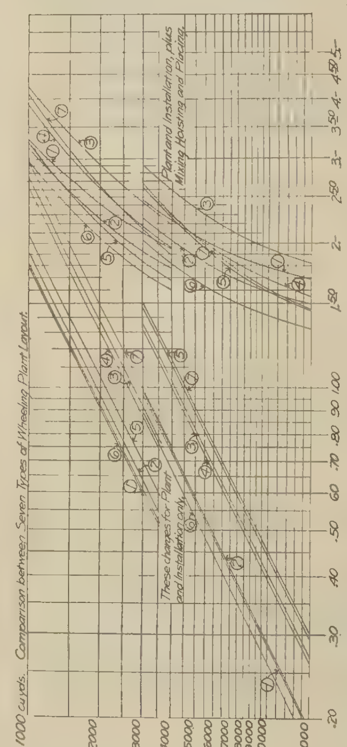
1. Mixer in pit. Charged by wheeling from adjacent stockpile.
2. Aggregate dumped from back-dump trucks against bulkhead. Labor required trimming pile but no wheeling to mixer.
3. Derrick added to No. 2 to handle from storage to bulkhead.
4. Mixer at grade. Overhead bin filled by derrick.
5. Overhead bin filled by bucket elevator from boat in street.
6. Belt conveyor delivers aggregate from boat in street to storage pile back of mixer bulkhead. Mixer in shallow pit to minimize dead storage below gates in bulkhead.
7. Aggregate handled to mixer from bin by 1 cu. yd. "V" cars operated by cable on double drum hoist. Track on light trestle to reach level of charging hopper.

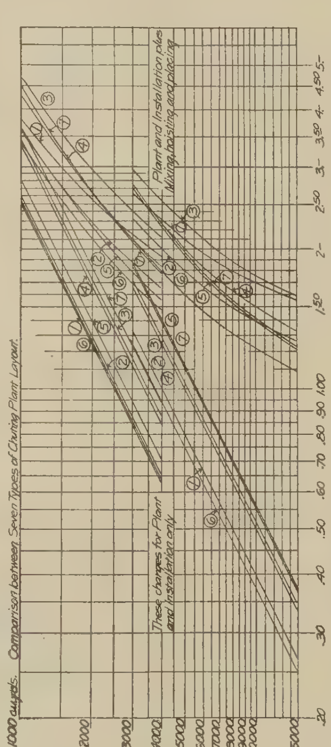
Fig. 1—Comparison between Seven Types of Wheeling Plant Layout

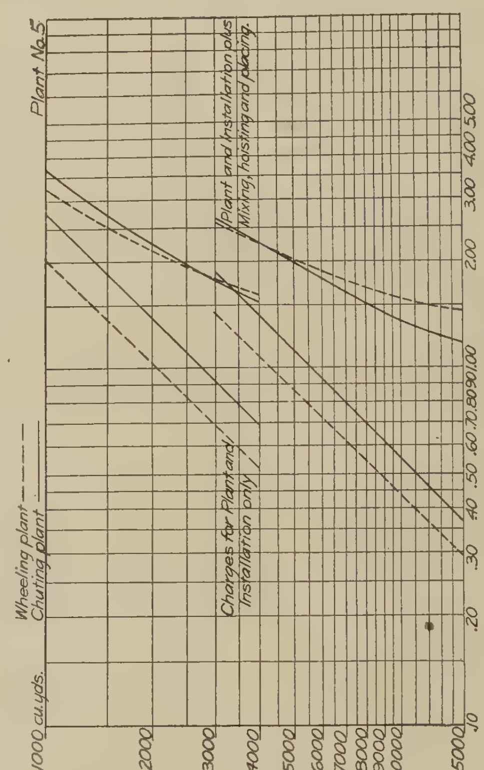
Fig. 2—Comparison between Seven Types of Chuting Plant Layout

Fig. 3—Comparison between Wheeling and Chuting for Plant No. 5

Fig. 4—Seven Different Plant Layouts







to the greater hoist, if the interval between batches is to be maintained.

The charging and placing gang will be about the same as where chutes are not used. The actual operators of the plant such as hoist runners, firemen, etc., will be about the same whether the concrete be transported by chutes or by carryalls. The cost of power whether steam or electricity is considerably greater for the chuting than for the wheeling plant due to the increased hoist necessary.

If due to special conditions such as the necessary transportation of considerable quantities of concrete long distances, it is decided that line chutes are more suitable, the special equipment will consist of principally:

Main hoist tower, generally of steel and of greater height than for either of the other layouts
Auxiliary towers or heavy anchorages
Line chutes and heavy supporting cables
Special auxiliary chutes with gates taking off from the line chutes
Special hoist bucket
Heavy guy lines and anchorages for towers
Heavier hoist equipment

The summary of the cost of each type of plant upon which the charts are based shapes up about as follows when all items are considered. The specific items of equipment given below are only for an example.

I—Plant

Wheeling		Chuting	
Equipment	Depreciation	Equipment	Depreciation
Mixer 1 yd.	20%	Mixer 1 yd.	20%
Motor 75 HP	20%	Motor 75 HP	20%
Single drum hoist	20%	Double drum hoist	20%
100-ft. Wood Tower ft. BM Lumber @ $ /M	100%	180-ft. Steel Tower	20%

Tower hoppers ft. BM Lumber @ $ /M	100%
Run panels & horses ft. BM Lumber @ $ /M	100%
1 yd. hoist bucket	20%
350 ft.—¾ in. hoist cable @	50%
1500 ft. ⅝ in. Guy Cable @	50%
12 Turnbuckles	
Wiring or Piping	100%
Concrete carts @	50%
1 add'l sliding frame with 54-ft. straight back hopper	20%
Full set of tower bolts	100%
800 ft.—¾ in. hoist cable	50%
20 Turnbuckles	
Sliding frame with Boom & Counterweight truss plant complete	20%
Blocks & tackle for boom	50%
Blocks for moving sliding frame, 1080 ft.—¾ in. cable	50%

Also include bins, bulkheads, conveyors, elevators, or other mechanical equipment, forming part of set up. Usually these items will apply equally to wheeling and chuting plants.

II—INSTALLATION

WHEELING — CHUTING

Excavation for grading for mixer plus sheeting and backfilling.
Setting up and dismantling motor, mixer and hoist.
Building & dismantling wood tower — Erecting & dismantling steel tower, rigging, chutes, etc.
Making floor hoppers
Making run panels & horses
Erection and dismantling of bins, bulkheads, conveyors, etc.
Electrical, plumbing and steamfitting work to connect up plant.

III—MAINTENANCE

WHEELING — CHUTING

Replacement of broken run-panels, horses and slides — Inspection, generally requiring an Ironworker foreman to tighten loose bolts, inspect tackler, etc.
Inspection

IV—OPERATING (CONCRETING)

WHEELING — CHUTING

Fuel or power, oil or waste
Labor mixing, hoisting & placing
  Men charging mixer
  Men handling cement
  Men on mixer
  Hoisting engineer
  Fireman (if any)
  Man on tower hopper
Men shifting run panels — Men handling chutes
Men wheeling on floor — Additional labor to raise sliding frame & shift guys and anchorages
Men spreading & tamping
Foremen
Men on mixer
Hoisting Engineer
Fireman (if any)
Man on tower hopper
Men wheeling on floor — Men on chutes
Men shifting run panels
Men spreading & tamping
Foreman

SECTION 2

The arrangements of plant most frequently used in building construction can be classified as modifications of seven general types.

To avoid the labor of repeated estimates of the cost of these layouts for different yardages it was suggested that the cost of each of these arrangements be platted in the form of a chart from which the cost per yard for plant and installation could be readily obtained.

The new charts which are presented this year are figured as follows:

(1) For each layout two sets of estimates have been prepared, one for wheeling and one for chuting plant.

(2) While a one-yard mixer is rarely used for jobs of less than 4,000 yards, the curves for one-yard plants have been carried down to 3,000 yards. Mixers of ¾-yd. capacity are often used for jobs up to 4,000 yards so that the ¾- and 1-yd. plant curves will overlap between 3,000 and 4,000 yds.

(3) For jobs of less than 4,000 yds. the equipment used for mixing, hoisting and placing is assumed as ¾-yd. mixer, 1-yd. hoist bucket, single drum hoist, 50 HP electric motor, 50-ft. wood tower, 8 concrete carts and 300 ft. of run panels.

For jobs of more than 4,000 yds. it is assumed that there would be used 1-yd. mixer, 1-yd. hoist bucket, single drum hoist, 75 HP electric motor, 125-ft. wood tower, 12 carryalls for placing and 400 ft. of run panels. One 30-ft. length of extension chute has been included.

Chuting equipment for jobs of all sizes is assumed as 1 yd. of the so-called "100-ft. radius" type, with which a double drum hoist would be used for convenience in raising and lowering the sliding frame. A ¾-yd. mixing plant would probably require not over a 120-ft. tower; for a 1-yd. plant a 180-ft. tower is commonly used.

The final decision on any *large* job should be made from a special estimate rather than from the charts; as a small difference per yd. will become quite important in the case of large yardages.

(4) Cost of plant to the job has been figured on a depreciation basis. The schedule below is reprinted from last year:

Bucket Elevator	40%
Carryalls	50%
Concrete Bucket	20%
Hoists	20%
Mixers	20%
Motors	20%
Side Tip Cars	20%
Steel Hoist Tower	20%
Stiff-leg Derricks	20%

INSTALLATION

Under installation was charged labor required to set up and dismantle the plant, as well as labor making up run panels, wood tower hoppers, conveyor supports, etc. Erecting steel hoist tower and hanging concrete chutes the first time is an installation charge. The subsequent moving of chutes about the floor, or the lifting of the sliding frame on the tower from floor to floor are charges against concreting.

POWER, ETC.

Power of fuel, oil, waste, grease, etc. have been included in the form of a flat charge of 12c per yd. of concrete. As this is an operating cost, as distinct from the plant depreciation and installation costs, it has been added to the labor unit for mixing, hoisting and placing.

INTEREST AND INVESTMENT

Interest and investment should be figured at 7% per annum on the value of the mechanical equipment put on the job. Wood-frame structures are not carried by the contractor, but like the form-lumber are bought for and used up on the one job, and their cost becomes a part of the cost of the work. As the period for which interest is figured will vary with the period during which the plant is on the job, it may either be put into the chart for an assumed average period, as was the depreciation, or it may be added in the summary. The latter method has been followed here.

These items comprise the charges against the plant for equipment and installation which are considered in the chart. To the total cost for plant, however, must be added the labor cost for mixing, hoisting and placing.

At the right of each chart is a set of curves in which this placing charge has been added to the plant cost. The labor unit is based on a rate of $4.50 for 8 hours, with labor efficiency at 100% as against approximately 90% for the corresponding time last year. The units used for the different plant layouts are given in Fig. 4.

LABOR

Labor, mixing, hoisting and placing embrace broadly the gangs charging and running the mixer, the hoisting engineer, man on the tower hopper and the floor, and the floor gang. The floor gang includes men wheeling, spreading and tamping as well as labor to lay and shift run panels or move chutes.

Time spent on receiving aggregate or cement is not included. It has been taken for granted that in receiving cement it would be piled alongside the mixer so that not more than two men would be required to open bags and empty into mixer hopper.

Plants 4 and 5 employ stiff-leg derricks. Their operation is not included in the cost of concrete as they would in all probability be used principally for unloading aggregate from cars or scows which would be a "receiving charge".

Effect of Sugar in Concrete Mix[1]

By Mariano Lora
Promoting Engineer Cuban Cement Co., "El Morro"

There are several kinds of organic matter, which when contained in the concrete mix may affect the chemical action of the cement, both as to the hardening and the strength of the concrete, causing considerable trouble and danger in concrete constructions.

Thus sugar is one of the impurities which may get access to concrete with a very destructive effect on the chemical as well as physical actions of the cement.

The author knows of several cases where sugar has had disastrous effect on concrete, principally in the construction of sugar plants. Among these occurrences, we quote the following, which caused this article—so that the importance of the subject to engineers and architects of concrete work in connection with sugar refineries, may be fully understood.

The Cuba Northern Railroad had its large repair shops built at Moron, in the province of Camaguey, by responsible contractors and under well known and reputable inspectors.

The concrete work progressed rapidly on the foundations and with apparently fine results owing to good materials and clever direction of the work. To the great surprise of the contractors and the inspectors, some of the foundations developed deficiences, the concrete would not harden and finally complete disintegration of that part of the concrete followed.

This partial failure of the work at first was inexplicable, and by itself caused a great deal of alarm and doubts as to the quality of the cement, which usually is the case, when no doubt can be entertained as to the other ingredients of the concrete—as the easiest way out of it.

On hearing of the accident at Moron, the promotion department of the Cuban Portland Cement Co. commissioned the writer to investigate the strange phenomenon, which had occurred, a usual custom by the publicity department of this company, in obtaining all possible knowledge pertaining to cement production.

The investigation was simple but conclusive. The inspector at the works had already obtained tests of the cements, all of creditable and well known brands, made from mortar briquettes of 1:3 mix, using the same sand which gave the bad results. These briquettes, after two days in the molds did not harden, and the mix remained a plastic mass similar in physical aspects to the defective work.

By a careful inspection of the different materials separately, it was found that the sand contained a foreign matter which proved to be sugar. As a matter of fact, one of the freight cars used in the transporting of the sand had previously hauled sugar, leaving a coating of sugar on the floor. The wet sand by capillary action absorbed a certain amount of the sugar, sufficient to totally destroy the chemical action of the cement. This fact, which escaped the engineer of construction, a gentleman of great knowledge and experience in concrete work, has been a costly lesson, but one of great value to those interested in concrete construction.

Afterwards a careful analysis was made of all the aggregates, the water, crushed stone and cement as well as the sand, and with the exception of the latter, showed good qualities. Particularly was the chemical analysis of the cement absolutely within the normal requirements, and the physical analysis of the cement exceeded the regular specifications for portland cement. From these inspections and tests in the field, as well as from our laboratory tests—the chief engineer of the Moron shops was convinced of the cause of the new phenomenon, which for the first time in his wide experience had presented itself, and expressing his great surprise, he added in his card: "Be sure in the future to avoid mixing sugar in concrete."

Charles A. Newhall, an engineer, recites a case similar to the one at Moron, which happened in 1913. An important piece of construction failed by disintegration of the concrete. The aggregates all were of excellent quality and subjected to a rigid inspection. It transpired however, that the cement had been transported in a steamer, which previously had carried a heavy cargo of sugar. A part of the cement bags burst and were afterwards refilled with cement containing sweepings from the floor, and it is unnecessary to state that this was the cause of the disaster. There are several similar cases, where trouble has resulted from carrying cement in bags in vessels used in the export of sugar from our country.

The experiences resulting from this phenomenon, and confirmed in our laboratory, demonstrate that even the small quantity of from ¼% to 1% in weight of sugar added to the cement, is sufficient to completely destroy its chemical action, and therefore the hardening capacity and strength of the concrete. In the Moron case the sugar content of the sand amounted to about 2%. When the cement contains between 1% and 2% of sugar, it sets rapidly, but it later completely disintegrates.

At present tests are being made to determine the minimum quantity of sugar chemically affecting the cement.

A recent case in an important work in Cuba is interesting, because the engineer in charge had heard of the case at Moron, and was taking every possible precaution to avoid a contact between sugar and the concrete in any form. The lumber which was used for forms had been stored in a sugar warehouse, but had been washed before being used in the work. However, six days after pouring the concrete the engineer to his surprise noticed that he could easily remove a layer from ½ in. to ¾ in. thick from the concrete surface, showing that the concrete had not set. After removing the forms, the concrete under the soft layer proved to be hard as rock, showing that the minute quantity of sugar that might adhere to the boards, had been sufficient to destroy the action of the cement for a thickness of more than ½ in.

Prof. Duff A. Abrams, of the Lewis Institute, Chicago, an eminent authority on the general problems of cement, and interested in the particulars of this phenomenon, stated in a recent conversation that the effect of sugar on cement is so intense that even the small quantity of $\frac{1}{10}$ of 1% of sugar will destroy the chemical action completely.

It is thought that this deleterious effect of sugar on cement is due to the formation of "saccharate of calcium", which prevents the formation of silicates and aluminates of lime, which in turn are the essential factors in the initial set and final hardening of concrete.

A more plausible and recent theory attributes the action to a physico-chemical reaction of a catalytical and coloidal art, as only in this way can be explained the enormous disintegrating effect of an infinitesimal

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[1] Translation by E. Lee Heidenreich.

EFFECT OF IMPURITIES IN SAND ON STRENGTH OF CEMENT MORTAR. ONE PART CEMENT, THREE PARTS SAND—BY WEIGHT.

Lot	%	Impurity in Sand	Water % in Dry Mix	Tensile strength 7 days	28 days	lbs. per sq. in. 90 days
I- 1	0		10	275	300	. . .
I- 2	0.14	agar	10	190	210	. . .
I- 3	1.0	agar	10	0	0	. . .
I- 4	0.14	starch	10	265	295	. . .
I- 5	0.14	tannin	10	140	230	. . .
I- 6	1.0	tannin	10	0	0	. . .
I- 7	0.14	glycerin	10	325	390	. . .
I- 8	1.0	glycerin	10	50	225	. . .
I- 9	1.0	sugar	10	0	0	. . .
I-10	1.0	linseed oil	10	0	0	. . .
I-11	1.0	heavy paraffin oil	10	270	340	. . .
I-12	0.014	tannin	10	190	340	. . .
I-13	0.014	glue	10	270	345	. . .
I-14	0.14	glue	10	220	319	. . .
I-15	1.0	glue	10	210	322	. . .
I-16	0.5	lime and tannin	10	0	0	. . .
L-1	0		10	233	380	443
L-2	1.0	zinc sulfide	10	238	368	410
L-3	1.0	iron sulfide	10	273	360	425
L-4	1.0	sulfur (S)	10	253	280	330
L-5	1.0	fatty acid (oleic acid)	10	198	295	385

quantity of sugar on a considerable quantity of cement.

Inasmuch as in our country most of our concrete work may be exposed to the danger from sugar, particularly about the refineries, we hope that the contents of this article may prove profitable to all those interested in cement.

To better illustrate this article we enclose a table, published by Kansas City Laboratories, entitled "*Cement and Concrete*", *Bulletin No. 11*, February 1921, from which may be found the disintegrating effect of different organic matters on cement.

Effect of Sugar on Cement Mortar

BY JULES DAUTREBANDE

TRANSLATED BY E. LEE HEIDENREICH

In *Le Ciment*

It is known that practical experience in several instances has permitted one to attribute a deteriorating influence and a destructive action of sugar on cement mortars and on concrete.

Thus Mr. Bonde, chief of the laboratories of the testing department of the firm Smidth, Copenhagen, has demonstrated that in a concrete construction at Copenhagen, with Danish cement and a mixture of 1:2:3, certain parts of the construction, principally columns, are not perfectly hardened, although in other points the concrete was unreproachable.

To investigate the causes which destroyed the effect of the cement, part of the non-hardened concrete was analyzed. Experiments were made with mortars of one cement and three sand to which had been added .01% sugar which caused reduction in strength of 10% after seven days, and with .25 to 5% of sugar the reduction was 90% compared with mortar without any addition of sugar. The cause was found to be the fact that the cement had been kept in sugar sacks.

Other practical examples of the influence of sugar on cement also had been related in the "Revue des Materiaux de Construction, et Travaux Publics de May 1919", particularly in a sugar factory where a wooden floor was covered with concrete. This floor had been cleaned, but not sufficiently, and still contained enough sugar to prevent the setting of the concrete to such an extent that the concrete surface was easily indented by the pressure of a finger.

In another case, we ourselves examined a concrete wall, which for some reason would not harden. We found the cement absolutely without fault, the sand was of good quality, but we found that the water contained more or less of sugar in solution, which influenced us to make experiments as to the effect of sugar on cement. The results were as follows:-

MIXTURE	FIRST SET	FINAL SET
Cement No. 1—		
Pure Water	4 hrs.	9 hrs. 10 min.
Water plus ¼% Sugar	1 hr. 55 min.	12 hrs. 30 min.
Water plus ½% Sugar	3 hrs. 45 min.	8 hrs. 15 min.
Water plus 1% Sugar	10 min.	5 hrs. 30 min.
Water plus 2% Sugar	7 min.	3 hrs. 15 min.
Cement No. 2		
Water (pure)	50 min.	3 hrs.
Water plus ¼% Sugar	5 min.	45 min.
Water plus ½% Sugar	5 min.	13 min.
Water plus 1% Sugar	5 min.	13 min.
Water plus 2% Sugar	1 hr. 50 min.	5 hrs. 50 min.

These tests show that the presence of sugar has the effect of hastening the first set of the cement, and as in practice often considerable time is spent in placing the concrete, the effect in reality amounts to retempering of the concrete with the result of reducing the strength. Besides, these experiments show that while the samples were perfect with pure boiling water, they were spoiled by hot water when ¼% sugar was added. With cold water, but little change was found in 28 days, only a small decrease in strength.

Action of Sugar Juices on Concrete

A LETTER FROM ERIE J. OCHS

CHIEF CHEMIST, COWELL PORTLAND CEMENT CO.

Occasionally one hears of complaints on the action of sugar juices on concrete, particularly the low grade sluice water. Herewith please find results of investigation bearing on this question:

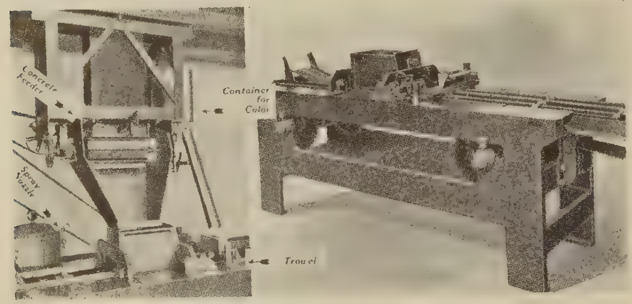
	7 Da.	28 da.	2 Mo.	3 Mo.	6 Mo.	9 Mo.	1 Yr.
Sands Standard (1:3)	325	457	513	492	492	462	487
Sands Standard Stored in Sugar Juice	. . .	. . .	487	515	485	520	500
Sands Standard 10% Sodium Silicate added	350	467	503	470	485	480	490
Sands Standard 10% Sodium Silicate, stored in sugar juice	. . .	. . .	528	532	537	475	475
Standard Briquette for 21 days, then *dipped 1 day, dried 1 day, for days*							
Sands Standard dipped in Sodium Silicate	. . .	445	515	513	527	462	487
Sands Standard dipped in Sodium Silicate stored in sugar juice	. . .	. . .	510	490	498	462	478

The thought in mind at the beginning of the investigation was porosity, and the belief that porosity might be the cause of some of the trouble, due to the waters permeating into the mass and attacking the lime, thus causing a slow disintegration. The above test specimens were made as impermeable as possible; one set was made according to standard specifications; another set was made with the addition of 10% sodium silicate. This sodium silicate was added to the mix water so that it would be uniform throughout the mass, and add an ingredient which would eliminate voids as far as possible. Another set was made according to standard specifications and after 21 days, was dipped in a 10% solution of sodium silicate for one day, dried for a day, and dipped and dried; this was done until the briquette was 28 days old, again using sodium silicate to exclude any acting solutions from the briquettes themselves. Before the briquettes were placed in contact with the acting sluice water, they were aged 28 days to approach somewhat the ordinary aging in practice; from then on they were in contact with the sluice water until the day they were broken.

As will be noticed from the tests, density seems to be the guiding feature in eliminating the action of the sugar juices on concrete, and I believe the above tests are sufficient proof that a well-made, dense and impermeable concrete will not show the disintegrating action of the sugar juices.

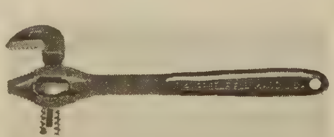
Hawthorne Tile Machine

The illustrations show the Hawthorne automatic equipment for the manufacture of concrete roof tile, made by the Concrete Tile Machinery Co., Cicero, Ill. The equipment is designed to make French or Spanish type tile; is of rigid and simple construction; all gears are enclosed, running in oil; all moving parts are protected from the damaging effects of concrete to machinery. An air-operated spraying equipment coats the pallet with oil. A feeding arrangement delivers the correct amount of concrete to the molding mechanism and a power-driven agitator delivers it to the tile. The concrete is compressed by tamping, the color is applied in a wet mix and troweled in. The machine links up with conveyor equipment which removes the tile to the curing space, without preliminary stacking. The manufacturers claim a production of 800 tile per hour or 40 squares a day, with two operators. The machinery is in use in Cicero, Ill., by the Hawthorne company, which has been making and marketing concrete roof tile for several years.



Little Giant Pipe Wrench

The Little Giant pipe wrench, shown in the picture, with several interesting features has recently been put on the market. It is end-opening for ease in handling pipes in corners, close to walls, and similar confined places. It can be set straight on the pipe like a pair of pliers. It has a double set of teeth on the main jaw. It is made in three sizes: 8, 10, 14, 18 and 24 in.

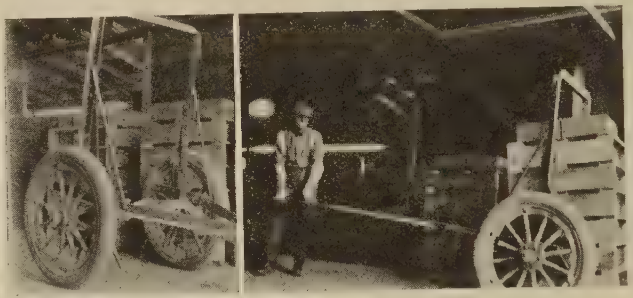


Little Giant Pipe Wrench

The Greenfield Tap & Die Corporation, Greenfield, Mass., the manufacturers, say the 14-in. size has withstood stresses in excess of 4700 inch pounds.

Cart for Concrete Building Unit

George W. Lynn, McIntyre Building Tile Co., Mt. Morris, Mich., built a cart for moving building tile away from the machine and cured tile to the yard. It is made out of two automobile wheels. "Racks handled by the cart are made of Norway 2-in. x 6-in. cut 27 in. long, with three pieces of Norway 1-in. x 4-in. cut 28 in. long nailed across from one to the other," says Mr. Lynn. "These are racked up 6 high, the bottom one has 2-in. blocks nailed on it to hold it off the floor that the hooks of the truck may readily get a hold; each rack holds 36 tile as a truck load. This auto outfit never breaks a tile and two men can wheel a load of 36 tile any place in the yard without any plank or anything to run it on but the rough ground.

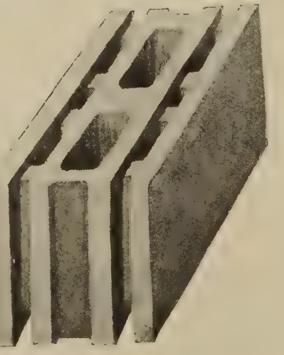


Two Views of Cart With Auto Wheels and Axle for Handling Building Tile

"I used the front axle and wheels complete from an automobile, and had a blacksmith bend the axle end to it. I clamped a 2-in. x 2-in. angle iron running back in a "V" form to the tongue. This wood tongue is 8 ft. long which gives plenty of leverage to lift the load; after the load is lifted it will almost balance without any help at all. The total cost of this outfit was less than $50.00, buying my auto parts of the auto wrecking house for $25.00; and I must say that it is very satisfactory."

Roeth Block

The accompanying illustration shows a newly patented type of concrete building unit to be made 8 in. high, 8, 10 and 12 in. thick, and 8, 16 and 24 in. long. The principal feature of the new patent is in the short ribs which terminate below the edges and just short of the ends of the tile. It is contended that there is formed an effective break at the mortar joints on all sides to prevent moisture seeping through the joints to the inside. This unit is patented by Albert H. Roeth, 105 Mt. Hope Place, Bronx, N. Y. It is not yet being manufactured nor are machines ready as yet to make it.



Roeth Building Unit

Waterproofing Concrete

The Swiss Waterworks' Association some time ago appointed a commission to investigate the various means which could be used for making concrete watertight, says *Schweizer Bauzeitung.* It first tried clay puddle, but eventually agreed that its use was accompanied by many difficulties and uncertainties; it is hoped, however, that tests now being made with mixtures of clay and sand may lead to better results. After investigating other waterproofing materials the commission reached the conclusion that the quality of the work rather than that of any added material is the chief factor. In other words, if the cement and aggregates are in proper proportions, if they are thoroughly mixed and the concrete well placed, there is no need for any waterproofing agents. Experiments made on concrete discs, 27 in. in diameter and 9 in. thick, which were placed in a vessel containing water under a constant pressure of 70 lb. per sq. in., showed that the blocks which were highly permeable at first rapidly lost their permeability, though even after three months they were still permeable. A curious feature of the results is that the drop in permeability is not regular, but increases for a few hours at various intervals, though the drop is, on the whole, very pronounced.

Bids Wanted for South Dakota State Cement Plant

The South Dakota state cement commission has asked for bids to be submitted to A. C. Hunt, secretary, at the commission's office in Rapid City, until noon on April 23, and from that date until noon of April 24, at the Marvin Hughitt hotel at Huron, South Dakota, for the construction of buildings at the site of the state owned cement plant near Rapid City.

The structures include reinforced concrete chimney, 205 ft. high; a one-story brick office, laboratory and employees locker room building; one-story brick shop and warehouse building; one-story and basement brick bag-storage and cleaning building; one reinforced concrete finished cement storage building, consisting of six 32 ft. in diameter by 70 ft. high tanks, cement packing house and accessories; concrete foundation for raw material storage building, 80 ft. x 408 ft.

Bids will also be received at the same time for furnishing and erecting reinforced concrete roofing tile for covering eight structural steel buildings of various sizes.

Plans and specifications for the structures and roofing are on file at the office of the South Dakota state cement commission at Rapid City, South Dakota, at the office of the J. C. Buckbee Co., Engineers, First Nat'l Bank Bldg., Chicago, Ill., and also at the office of the secretary of the Associated Contractors of the state of South Dakota at Aberdeen, South Dakota.

The recently issued Recommended Minimum Requirements for Small Dwelling Construction of the Building Code Committee of the Department of Commerce, recognizes expanded metal lath and plaster on wood joists and studs as a satisfactory interior for attached or built-in garages, and also for party or division walls between dwellings. Many cities have no regulations and permit ordinary lath, and other cities have too rigid a regulation.

New Books

Concrete Construction—By DeWitt C. Pond. Size 6 in. x 9 in.; 204 pages; illustrated. Price $4.00. Charles Scribner's Sons, 597 Fifth Ave., New York.

In this book the author, who is identified with the office of one of the large architectural firms in the country and who has had charge of the various engineering problems in the construction of many large factories and industrial buildings of reinforced concrete, presents a concise treatise on the design of reinforced concrete slabs, beams, girders, columns and footings, and a description of the actual design of a concrete building involving the use of flat slab construction. The book is fully illustrated with drawings of special engineering features, representative of up-to-date practise and the design principles by diagrams.

New Building Estimators' Handbook, by William Arthur, Size 4½ in. x 7 in.; 1002 pages; illustrated. Flexible binding; Price $6.00. U. P. C. Book Co. Inc., New York city.

In bringing the Building Estimators' Handbook up to date with this edition there has been an endeavor to give actual time, labor and material required on every operation in all classes of work. It is a guide book for use in preparing estimates, based on actual present day conditions.

The information contained is in concise form and the essential facts given for the practical purposes of a building estimator.

In addition to the ordinary mathematical tables useful for every day reference, in a book of this sort, some special tables have been added that will facilitate the calculation of building quantities, such as a series of tables for estimating, plastering, etc.

Chapter I is devoted to measurements on building work. This includes trade rules and some of the established systems for measurements. Other chapters are devoted to concrete work, reinforced concrete and cement stone.

Practical Accounting for the General Contractors, by H. E. Grant, Size 6 in. x 9 in.; 254 pages; price, $3.00. McGraw-Hill Book Co. Inc., New York city.

The results of years of experience with the installation of practical accounting methods in the contracting field are made available in this book, the text being so written as to apply helpfully to the problems of the small contractor no less than those of the large ones. The accounting system evolved by the author was devised to fit the contractor's peculiar needs. The system of accounts and accounting control evolved fulfilled the essential requirements by giving the contractor the information he requires for the management of his business promptly and at a time when he can make use of it.

The book is divided into three parts, covering financial accounting at the home office, cost accounting control, and part three dealing with payroll problems, control of equipment, etc. An appendix contains standard forms of contract between owner and contractor.

Materials of Construction, by H. E. Pulver, B. S., C. E., Size 6 in. x 9 in.; 318 pages; illustrated; Price $3.00; McGraw-Hill Book Co. Inc., New York city.

This is a clear and simple treatise in the form of an elementary text book on the type, manufacture, properties and uses of building materials. It is prepared for use in a correspondence study course offered by the Extension Division of the University of Wisconsin. The book is provided for the use of students who have had an ordinary training in English and arithmetic.

The various materials of construction touched upon are: plasters and natural cements; limes and lime mortars; portland cement; portland cement mortars; concrete; clay products; stone and brick masonry; timber; iron; steel; non-ferrous metals and their alloys; as well as miscellaneous materials such as paint, glue, paper, etc.

The Design of Masonry Structures and Foundations, by Clement C. Williams, C. E.; Size 6 in. x 9 in.; 550 pages, illustrated; price, $5.00; McGraw-Hill Book Co., New York city.

This first edition is an up-to-date treatise on the subject and reflects the latest developments and researches, treating the design of masonry structures from the aspects, stability, economy and architectural appearance. It fills a recognized need in the field covered.

A brief historical review of masonry construction is included and in presenting the chapters on concrete and reinforced concrete, no attempt was made to treat the subject of reinforced concrete completely, a knowledge of mechanics on the part of the reader being assumed and the material being presented for reference and to provide for those readers who have not previously pursued a course in the subject.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., REQUIRED BY THE ACT OF CONGRESS OF AUGUST 24, 1912

Of CONCRETE, published monthly at Detroit, Michigan, for April 1, 1923.

State of Michigan, }
County of Wayne, } ss.

Before me, a Notary Public, in and for the State and County aforesaid, personally appeared R. Marshall, who, having been duly sworn according to law, deposes and says that he is the General Manager of CONCRETE, and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and, if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in Section 443, Postal Laws and Regulations, printed on the reverse side of this form, to-wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are:

Publisher—Concrete-Cement Age Pub. Co., Detroit, Mich.
President—R. Marshall, Detroit, Mich.
Managing Editor—Harvey Whipple, Detroit, Mich.
General Manager—R. Marshall, Detroit, Mich.

2. That the owners are (Give names and addresses of individual owners, or, if a corporation, give its name and the names and addresses of stockholders owning or holding 1 per cent or more of the total amount of stock):

Concrete-Cement Age Pub. Co., 1807 E. Grand Blvd., Detroit, Mich.
R. Marshall, 1807 E. Grand Blvd., Detroit, Mich.
Harvey Whipple, 1807 E. Grand Blvd., Detroit, Mich.
F. F. Lincoln, Room 1205, 115 Broadway, New York City.
R. N. Jackson, 1807 E. Grand Blvd., Detroit, Mich.
R. W. Lesley, Pennsylvania Bldg., Philadelphia, Pa.
Edward B. Bruce, Manila, P. I.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities, are: (If there are none, so state.) None.

4. That the two paragraphs next above, giving the names of the owners stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company, but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest, direct or indirect, in the said stock, bonds, or other securities than as so stated by him.

5. That the average number of copies of each issue of this publication sold or distributed, through the mails or otherwise, to paid subscribers, during the six months preceding the date shown above is———. (This information is required from daily publications only.)

R. MARSHALL,
Manager.

Sworn to and subscribed to before me this 28th day of March, 1923.
(Seal.) IONE MICHAEL.
(My commission expires April 9, 1923.)

Engineering Economics—Second Edition, by John C. L. Fish, Professor of Railroad Engineering, Stanford University; 311 pages; 6 in. x 9 in.; illustrated; price $3.00. McGraw-Hill Book Co., Inc., New York city.

This second edition is more than a revision. It is practically an entire new text. Features of organization, control and management of corporations and the principles of business statistics and cost keeping, which every engineer should know, are included. It is a sound discussion of fundamental economic principles, prepared because engineering knowledge can be converted into community service only through the medium of business, and because consequently the engineer's professional success and his contribution to public welfare depend in a great measure on his understanding of the business side of engineering—engineering economics.

Included in the contents are chapters on: Interest; Analysis of Problems of Investment; Preliminary Analysis of First Cost and Operation Cost; Business Statistics; Valuation; Errors in Estimating; Engineering Reports.

Structural Drafting and the Design of Details. Second Edition, by Carlton Thomas Bishop; Size 10 in. x 7½ in.; cloth covers; 352 pages; illustrated; John Wiley & Sons, Inc., New York city. Price, $5.00 net.

This new second edition, made necessary because of extensive changes in the standards of the Association of American Steel Manufacturers, contains many other changes and corrections in order to keep the book up to date. The book was originally written to meet the requirements of the courses in structural drafting and structural design at Yale University and has since been adopted by about 15 other institutions as a text book.

The general arrangement of the book makes it convenient reference book and the size of page permits clear illustrations. The entire subject of structural drafting is covered in a clear concise manner beginning with several pages of definitions of term pertaining to the material covered in the book. Th necessary tables and diagrams are included, permittin the designer or draftsman to carry out ordinary wor without the tables in the usual manufacturer's hand book.

Home Instruction for Sheet Metal Workers, Willia Neubecker, edited by Frank Morio, Size 6 in. 9 in.; 404 pages; illustrated; U. P. C. Book, Inc. New York city. Price, $5.00.

This book, with accompanying folding charts, in cludes detailed instructions on cutting, forming soldering, preparing full size details from architect blue prints, developing the patterns, laying out th work on sheet metal, forming and bending on th brake and assembling. The aim of the book is no only to assist the apprentice helper and the mechani to understand the theory of the subject but chiefly t help him master the practical side of sheet meta work. The book is for the most part composed practical problems. These practical problems hav been arranged in sequential order according to the difficulties. References are made from one proble to another, pointing out the similarity of metho employed or the principle used. The material is base on a series of articles originally published in *Met Worker, Plumber and Steam Fitter.*

Concrete Institute Changes Name

The name of the Concrete Institute, the English organization having a membership of over 1000, has been changed to "The Institution of Structural Engineers".

The change of name was the natural outcome of the work the organization had been doing in the past, and was due to a desire to express the work its members had been doing and were continuing to do in a more logical manner than they had hitherto done.

In order to impress upon themselves and upon the whole world what their sphere of usefulness was, the members of the Institute felt that it was right that they should take a title which would convey the proper meaning.

Industrial Association Trains Men in Trades

The Industrial Association of San Francisco is doing a good work in meeting that district's part of the nation-wide shortage in building workmen. Its plastering and plumbing schools have turned out more than 325 boys and men who have, without exception, "made good" and now are steadily employed. Plastering and plumbing contractors say that without these trained men they would have suffered material loss and delay in carrying on their work. The school for plasterers is now operating evenings as well as days; the evening class having been established to permit journeymen to become more proficient in ornamental plastering.

Three more free trade schools were opened in January by the association: they are to teach iron and brass molding, bricklaying, painting and paperhanging.

It is noteworthy that San Francisco went through the year 1922 without a single job or jurisdictional strike, and that the value of building permits showed an increase of 115% over 1921, as compared to a country-wide increase of 53%. Building activity in San Francisco is increasing, it is asserted, and 1923 promises to be a "banner year."

The Dodge Sales and Engineering Co., Mishawaka, Ind., which has for the past eight years been operating as the selling subsidiary of the Dodge Manufacturing Co., and Dodge Steel Pulley Corp. has been consolidated with the parent company, the Dodge Manufacturing Corp., which was organized and began business last July.

Since July 1922 the manufacture of Dodge, Oneida and Keystone power transmission appliances and Dodge Heavy Oil Engines has been conducted by Dodge Manufacturing Corp.

Trade Publications

Porete Roof Decks, Circular No. 12 and *Porete for Fireproof Roof-Decks*, Cicular No. 13, by the Porete Mfg. Co., Newark, N. J. Circular No. 12 is a one page circular 9 in. x 11 in., illustrating and describing porete base for slate or tile.

Circular No. 13 contains reasons given as to why Porete should be specified, specifications for roof-decks, miscellaneous data on Porete roofs and data as to spacing of purlins supporting roofs covered with Porete slabs.

Universal Form Clamps and Bar Spacers, by the Universal Form Clamp Co., Chicago. This catalog descriptive of Universal concrete building accessories is 9½ in. x 11 in.; 46 pp.; paper covers. Universal form clamps, tightening wrenches, rod pullers, bar chairs and wire clamps are described and illustrated. Considerable valuable information is contained for design of concrete forms.

The Stewart Concrete Mixer Book, No. 23, Stewart Mfg. Co., 124 Rath St., Waterloo, Ia., J. H. Stewart, president of the company, relates the designing and building of mixers since 1905, and follows this statement with detailed descriptions of the various Stewart mixing equipment, with illustrations, and a more or less detailed analysis of the construction of the Stewart machine and its special mixing features.

Godwin steel paving guards are illustrated and described in detail and in use in a booklet issued by the W. S. Godwin Company, Inc., 12 E. Lexington Street, Baltimore, Md. The Godwin guards are for various uses in connection with paving. One type is for the exposed edge of concrete curbs, platforms, steps, and so on. Another type is to protect the edge of the pavement where disintegration frequently starts. Another separates steel rails from the paving proper so that the steel rail, a filler, and the steel guard which is anchored into the concrete, provide the necessary play and resiliency to prevent pavement destruction at this rather vulnerable point. Still another type is a dividing plate for use longitudinally throughout the length of concrete roads, so that the two longitudinal sections of wide roads now being laid may be put down at one operation and yet have requisite separation at each joint, by means of the plate and by steel reinforcing dowels, if desired, placed through the plate.

Organizations

American Concrete Institute; Harvey Whipple, Secretary, 1807 East Grand Boulevard, Detroit. Convention February 25 to 28, incl., 1924; place undecided.

American Concrete Pipe Association; M. W. Loving, Secretary, 111 West Washington St., Chicago.

American Engineering Standards Commission; Dr. P. G. Agnew, Secretary, 29 W. Thirty-ninth Street, New York City.

Associated General Contractors of America; G. W. Buchholz, Secretary, 1038 Munsey Bldg., Washington, D. C.

Associated Metal Lath Manufacturers; 123 W. Madison St., Chicago; Wharton Clay, Commissioner.

Building Officials Conference; Rudolph P. Miller, President, Fred W. Lumis, City Hall, Springfield, Mass., Secretary. Annual meeting April 24-27, inclusive, in Toledo, Ohio.

Iowa Cement Stave Silo Association; H. E. Kilmer, Secretary, Oskaloosa, Ia.

Iowa Concrete Products Association; Ross Dowell, Secretary, 405 Hubbell Bldg., Des Moines.

Mid-West Concrete Products Association; D. R. Donlen, Secretary-Treasurer, 4340 Marcy St., Omaha, Neb.

The National Concrete Stave Silo Association; W. G. Kaiser, Secretary, 111 West Washington St., Chicago.

National Crushed Stone Association; A. P. Sandles, Secretary, 405 Hartman Bldg., Columbus, Ohio.

National Housing Association; Lawrence Veiller, Secretary and Director, 105 East 22nd St., N. Y. C.

The National Lime Association; Mather Bldg., Washington, D. C.

Fifth Annual Convention, Hotel Commodore, New York city, June 13, 14, 15, 1923.

National Sand and Gravel Producers' Association; T. R. Borrows, Acting Secretary, 903 Munsey Bldg., Washington, D. C.

Portland Cement Association; William M. Kinney, General Manager, 111 West Washington Street, Chicago.

Wisconsin Concrete Products Association; D. R. Collins, Secretary-Treasurer, Milwaukee.

R.I.W.

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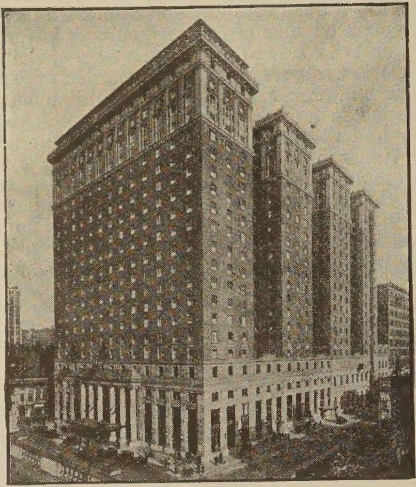

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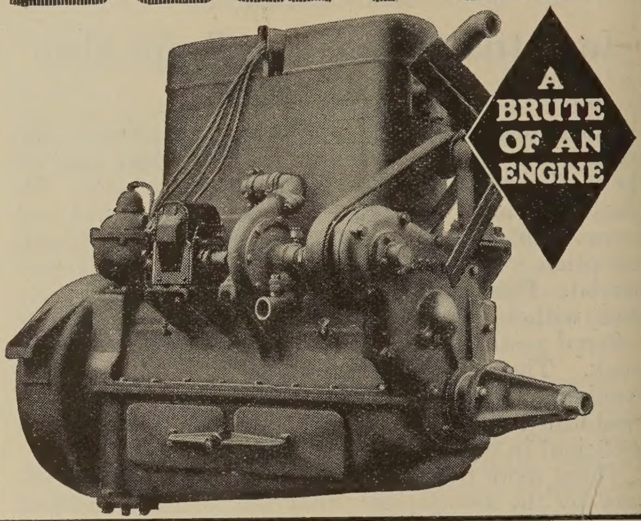

A BOOK ABOUT
CONCRETE HOUSES

In its 215 large pages are described all the successful methods of building concrete houses— actual details and figures of cost on houses that have been built. Covers solid wall, hollow-wall, block, brick, tile and large cast unit construction. There are 356 illustrations from photographs and pen drawings. Bound in stiff brown boards.

Price $3.00 postpaid in the United States
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